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Effect of Autonomy on Children's Moderate to Vigorous Physical Activity, Enjoyment, and Competency During High-Intensity Interval Training in Physical Education.

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Effect of Autonomy on Children's Moderate to Vigorous Physical Activity, Enjoyment, and Competency During High-Intensity Interval Training in Physical Education.

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Abstract

Effect of Autonomy on Children's Moderate to Vigorous Physical Activity, Enjoyment, and Competency During High-Intensity Interval Training in Physical Education.

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PURPOSE: Little is known about children's enjoyment and competency with HIIT during school, and no efforts have been made using Self-Determination Theory (SDT) to make school based, HIIT interventions more accepted by children. The purpose of this study is to describe children's physical activity levels, enjoyment, and competency of HIIT within a SDT framework (autonomy) in elementary school physical education (PE) classes. The study will further explore children's enjoyment and competence towards high intensity, low intensity, and strength activities. METHODS: Participants were 402 children from one diverse elementary school (49.4% female, 21.1% Latino or Hispanic, 59.6% white). Student enjoyment and competency were collected from each child following teacher (non-autonomous) and student led (autonomous) conditions. 201 children wore accelerometers to measure moderate-to-vigorous physical activity (MVPA). Enjoyment and competency were assessed for each activity type (high, strength, and low). ANALYSIS: The primary hypotheses were assessed through a series of 2-way ANOVAs;

2 (condition) x 2 (sex) x 4 (grade), with repeated measures on the first factor (condition). A 4 (grade) by 2 (sex) MANCOVA on enjoyment and competence for type of activity (high, strength, low). RESULTS**:** Children significantly enjoyed (*M*=4.52, *SD*=0.87) and felt more competent (*M*=4.45, *SD*=0.74) during the autonomous HIIT condition compared to the nonautonomous HIIT condition, (*M*=4.08, *SD*=1.09; *M*=4.36, *SD*=0.80); percent MPVA was significantly lower in the autonomous condition (*M*=41.89, *SD*=12.16) compared to the nonautonomous condition (*M*=54.77, *SD* =11.51). Females enjoyed low intensity activity significantly (*M*=4.56, *SD* =0.55) more than males (*M*=4.38, *SD* =0.69) and males enjoyed high intensity (*M*=4.17, *SD* =0.72) and strength activities (*M*=3.96, *SD* =1.01) significantly more than females (*M*=3.95, *SD* =0.75; *M*=3.67, *SD* =1.11).

CONCLUSION: Girls across grades tended to enjoy lower intensity activity, while boys enjoyed high intensity and strength activities. In addition, the inclusion of choice to provide a sense of autonomy increased enjoyment of HIIT, which was associated with competence, but lowered physical activity intensity. These data can be used to inform the design of school based, HIIT interventions.

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Introduction

CARDIOVASCULAR DISEASE, PHYSICAL ACTIVITY, AND PHYSICAL FITNESS

Cardiovascular disease (CVD) remains the leading cause of death worldwide (World Health Organization (WHO), 2020; Xu et al., 2018). In the United States, over half a million citizens died from heart disease in 2017, while 12.1% of adults were diagnosed with the condition (Benjamin et al., 2019). This dire health problem consists of a number of diseases including coronary heart disease, stroke, hypertension, and heart failure. Coronary artery disease (CAD) is the most common form of CVD, accounting for about 50% of all CVD cases (Benjamin et al., 2019). Cardiovascular diseases can be prevented by targeting modifiable risk factors. Two of these major risk factors are physical inactivity and low physical fitness (Powell et al., 1987; Lee et al., 1996). It is important to note that physical activity and fitness act independently to protect against cardiovascular risk factors and as a preventative measures against obesity, a separate modifiable CVD risk factor (Andersen et al., 2006; Weiss & Raz, 2006). However, there is evidence showing a positive association between moderate-to-vigorous physical activity (MVPA) and cardiovascular fitness, that may be primarily driven by vigorous intensity activity (Hay et al., 2012). Moreover, moderate and vigorous intensity activities are associated with improvements in CVD risk factors, while low intensity associations are less strong and clear (Janseen & LeBlanc et al., 2010). These same patterns are observed among children, as levels of physical activity have been shown to predict the clustering of CVD risk factors (Andersen et al., 2006; Froberg & Andersen, 2005). Thus, from a public health perspective, primary prevention of CVD in childhood is critical because physical inactivity, low fitness, and their individual associations with other CVD risk factors can begin in childhood and adolescence, and track into adulthood (Hallal et al., 2006; Telama et al., 2005). This highlights the importance of targeting physical activity and fitness from an early age.

CHILDREN'S PHYSICAL ACTIVITY

While there are clear health benefits, American children are not participating in optimal levels of physical activity (U.S. Department of Health and Human Services [HHS], 2016; Andersen et al., 2006). In fact, approximately 24% of children ages 6-17 years met the physical activity guidelines of 60 or more minutes per day 7 days/week in 2016 (HHS, 2016). Of particular concern is that physical activity levels decline with increasing age as 42.5%, 7.6%, and 5.1% of 6-11 years old, 12-15 years old, and 16-19 years old met the guidelines (Centers for Disease Control (CDC), 2006). These patterns of activity have been stable over the last 10 years, suggesting that existing public health efforts may be ineffective (DHHS, 2016) and highlight the need for more effective intervention efforts to protect the health of children.

CHILDREN'S PHYSICAL FITNESS

Fitness is defined by the ability to carry out daily tasks with vigor and alertness, and compromises several domains including: aerobic fitness, muscular strength, muscular endurance, balance, agility, flexibility, and body composition (DHHS, 2018). As is the case for physical activity, physical fitness among American children remains inadequate and declines over time (HHS, 2016). Specifically, 42% of older youth have adequate amounts of cardiorespiratory fitness (Borrud et al., 2012); 52% of children ages 6 to 15 years old have adequate muscular endurance (Borrud, 2012); and 5.3% of boys and 12.1% of girls ages 15 to 19 years old fall in the "excellent" Health Benefit Zone for grip strength, an indicator of muscular strength (DDHS, 2011-2012). While an important, independent predictor, there is some evidence to suggest that the cardiovascular benefit of physical activity is highest in low fit children (Brage et al., 2004).

Thus there should be added attention on improving physical activity among these low fit youth, particularly because unfit individuals, regardless of body-mass index (BMI), have twice the risk of CVD death compared to those who are fit (Barry et al., 2018). Therefore, both fitness and physical activity need to be central components of interventions focused on improving heart disease risk.

School-Based Interventions

Given that children spend up to 30 hours each week at school – with 73% of this time sedentary – school-based interventions provide the optimal environment to target children's physical activity behavior (Carson et al., 2014). In fact, school-based interventions have increased physical activity among children (van Sluijs et al., 2007; Heath et al., 2012), while simultaneously providing positive effects on the prevention of obesity (Wang et al., 2015). These school-based physical activity interventions typically incorporate one or more components of the Comprehensive School Physical Activity Program (CSPAP; Kriemler et al. 2011; CDC, 2013). The CSPAP is a framework for schools and school districts to encourage children's physical activity by using all opportunities for students to be physically active (CDC, 2013). The components include enhancing Physical Education (PE) classes, daily recess, physical activity before and after school, family and community engagement, staff involvement, and physical activity during school. While all of these components are important to increasing children's daily physical activity, the CDC determined PE to be the foundation for promoting physical activity in schools (2013). Moreover, PE is the only CSPAP component that all states mandate (National Physical Activity Plan Alliance, 2018). Thus, PE class is the only consistently structured, nationally set aside time during the school day when every child can learn skills and knowledge for lifelong physical activity endeavors while engaging in physical activity.

Physical Education Limitations

While PE has the potential to the support children for the enjoyment of a lifetime of activity and health, PE instructional time remains limited and the levels of MVPA accrued in PE is insufficient. The limited time allocation for PE is in part due to the passing of the No Child Left Behind Act in 2002 that resulted in 62% of elementary schools reallocating time to “core” subjects, with 44% of those schools cutting time specifically from PE, art, music, social studies, and recess (Center on Educational Policy, 2008). Additionally, the variability in state’s PE policies combined with only 22 states mandating a minimum number of PE minutes are likely contributing to PE time restrictions and low physical activity levels during PE (Kahan & McKenzie, 2017). Moreover, the reduction in physical activity participation from childhood through adolescence (National Center for Health Statistics, 2005-2006) aligns with the percentage of schools requiring PE decreasing with each grade from 97.3% in 6th grade to 42% in 12th grade (Brener et al., 2016). The CDC (2010) recommends that a quality PE program should provide 150 min/week in elementary schools and 225 min/week in middle schools with students engaging in MVPA at least 50% of the time. However, less than 50% of PE is spent engaged in MVPA across schools nationwide, with much of class time spent in administrative and management tasks (McKenzie et al., 2000; Simons-Morton B.G., 1994; Jago et al., 2009). In addition, while there have been successful school-based interventions aimed at increasing MVPA during PE (McKenzie et al., 1996; Sallis et al., 2012), it is not known if the programs have been successfully adopted and implemented in schools following the completion of the studies (Sallis et al., 2012). Further, one recent review revealed that despite these existing efforts to improve MVPA during PE, elementary school PE classes continue to not meet the CDC guidelines, with children spending 32.6% of PE lesson time in MVPA (Hollis et al., 2017). Clearly the recommendation by the CDC might be overly ambitious given the evidence that time is limited for PE class nationwide.

One challenge in increasing time spent in MVPA during PE might stem from conflict with its primary mission: to provide students with the knowledge, skills, competency, and enjoyment to be physically active for life (SHAPE America, 2015). This objective can be unaligned with achieving the optimal MVPA as time spent teaching skills and building efficacy have been measured at lower levels of intensity (McKenzie et al., 2000). While this may result in less MVPA in the near term, these skills are likely critical for future health as more skilled students are generally more active than less skilled (Fairclough, 2004; Li and Dunham, 1993). This confirms the importance of motor skill development and fostering various enjoyable experiences during PE class for all students. Lack of competency and enjoyment for a task has detrimental effects to sustained activity participation (Rink, 1994; Kremer et al., 1997; Wankel, 1993). Thus, it is not surprising that PE teachers emphasize time teaching skills - especially given the limited time for PE during the school week. The challenge for public health scholars is, then, to develop interventions to balance the need for greater levels of MVPA with the primary mission to teach fundamental motor, cognitive, social skills that are needed to truly ensure lifelong activity and health.

HIGH-INTENSITY INTERVAL TRAINING FOR CHILDREN

While PE has the potential to reach the broad U.S. population of children, there is clearly a need for adoptable and innovative solutions to address the low amounts of MVPA within the existing time constraints and competing goals. High-intensity interval training (HIIT) could pose as a PE strategy/addition to increase physical activity levels, fitness, and cardiovascular health, while also providing ample time for teaching fundamental PE objectives. The 2018 Physical

Activity Guidelines for Americans emphasize that children should not just engage in moderate intensity activity but include at least three days per week of vigorous activity (Piercy et al., 2018). This is because of the added cardiorespiratory training that improves fitness provided by vigorous activity that can also build children's self-efficacy for engaging comfortably in lifelong physical activity behaviors (Piercy et al., 2018). Moreover, children's natural tempo and activity levels are observed as short bursts of high-intensity physical activity followed by intervals of low or moderate intensity PA (Bailey et al., 1995). Thus, HIIT might be preferred by children as it mirrors this natural pattern of movement. Given the nature of HIIT and variability in training protocols, it might be an appropriate strategy for improving children's vascular health and activity levels during PE. HIIT protocols and studies have various definitions of what constitutes high-intensity exercise, but a recent meta-analysis defined HIIT is as an exercise stimulus greater than or equal to 70% $VO2_{peak}$ or the equivalent of HR_{max} that corresponds to an intensity in the upper boundary of the moderate level of PA because this likely provides a stimulus greater than lactate threshold (Bond et al., 2017). Exercise protocols for HIIT consist of short bouts of vigorous intensity periods of activity intermixed with periods of rest that are typically carried out by different modes of activity (e.g. sprints, cycling, body weight, rowing) (Bond et al., 2017).

Physiological Benefits of HIIT For Children

High intensity interval training provides a host of cardiovascular benefits that have proven to be equal or often superior to a comparable continuous dose of moderate physical activity (Bond et al. 2017; Corte de Arajuo et al, 2012). The evidence is strong supporting HIIT to improve CRF, vascular function, and body composition compared to continuous moderate intensity training in clinical and nonclinical adult samples (Ramos et al., 2015; Kessler et al., 2012). However, the evidence for these benefits is less studied in youth, with very few studies measuring responses to HIIT in elementary age children. Among adolescents, Costigan and colleagues (2015) determined that HIIT improved both CRF and body composition when compared to low-moderate aerobic endurance training. One recent meta-analysis exploring effectiveness of HIIT in both overweight and obese children and adolescents found greater reductions in systolic blood pressure (SMD = 0.39; -3.63 mmHg) and increases in VO2max (SMD = 0.59, 1.92 ml/kg/min) in youth participating in various HIIT programs compared to control groups (i.e. moderate intensity continuous training, moderate interval training, lower intensity interval training) (Garcia-Hermoso et al., 2016). One of the few studies to measure the impact of a HIIT program on fitness in non-obese/overweight prepubertal elementary aged children found that those who performed 20 minute HIIT sessions biweekly over 12 weeks demonstrated significant improvements in motor capacity and aerobic fitness compared to the moderate intensity aerobic exercise control group (Martinez et al., 2016). Finally, Chuensiri et al., (2015) determined that HIIT had favorable effects on a group of 16 preadolescent boys' vascular function, CRF, and resting metabolic rate when compared to the sedentary control group of boys. The pronounced improvements to vascular function can be explained by the decrease in arterial stiffness and increase in endothelium-dependent brachial artery vasodilation that could ultimately lead to a chronic vascular benefit for these children (Chuensiri et al., 2015). In fact, arterial stiffness is considered to be one of the earliest measures of vascular dysfunction, thus making HIIT a potentially potent lifestyle treatment for children with premature arterial stiffening (Cote et al., 2015). Ultimately, evidence touting the cardiovascular benefits of HIIT for children is limited likely due to the challenges of completing experimental exercise training studies in this population. Children's attendance to exercise programs relies heavily on the parent's availability, with dropout from traditional training programs being high likely due to the time commitments (Sola et al., 2010). The abbreviated training sessions of HIIT, integrated within the school day might help to mitigate time as a barrier for parents and children. However, there remain questions about children's experience with HIIT.

Self-Determination Theory

While some evidence exists to support the health-benefits associated with HIIT in youth, a more recent meta-analysis argues for developing interventions that promote children's enjoyment and acceptability of HIIT (Bond et al., 2017). Self-Determination Theory (SDT) can be used as framework to influence sustained physical activity participation within an exercise experience (Deci & Ryan, 1985). Ryan and Deci (2000) identified three psychological needs - autonomy, competency, and relatedness - that are essential in a social environment for facilitating intrinsic motivation. While there are several forms of motivation, intrinsic motivation is distinctly important to foster in children's physical activity behaviors because it promotes inherent satisfactions with an activity and is regulated by enjoyment (Ryan & Deci, 2000). A sub-theory of SDT, cognitive evaluation theory (CET), suggests that the strongest facilitators of intrinsic motivation are the satisfaction of autonomy and competence so long as the activity remains enjoyable (Ryan & Deci, 2000). Based on these theories, efforts to incorporate autonomy and competency constructs of SDT within a HIIT intervention for children are likely critical to sustainable implementation in PE and children's intrinsic drive to be active.

Autonomy and Physical Activity

Autonomy or choice is defined as regulation by the self (Ryan et al., 2009). Choice represents one of the central needs that promotes intrinsically motivated behaviors such as engagement in physical activity. Autonomy will be manipulated in the current study because it has been shown that when teachers provide autonomy support, all three psychological needs are met in students (Standage, Duda, & Ntoumanis, 2006). While autonomy is an internal feeling or state, social environments can be controlling or autonomy supportive, which impact one's ability to act autonomously (Ryan et al., 2009). This model has been well studied in the classroom in that autonomously motivated students tend to succeed, and autonomy-supportive teachers greatly affect student's motivation in school (Reeve, 2002). Within the PE context specifically, similar findings demonstrate that when students experience autonomy supportive PE opportunities, they experience increased skill level attainment, perceived competence, and physical activity (Hastie et al., 2013). To our knowledge, there are no studies manipulating autonomy during HIIT to understand how children's enjoyment, competence, and physical activity are impacted.

COMPETENCE AND PHYSICAL ACTIVITY

In addition to autonomy, competence is one of the psychological needs that supports intrinsic motivation. Competence is generally defined as one's perception of skill or ability in a behavior domain such as physical activity (Ryan et al., 2009). A student's feeling of competency is supported when teachers or coaches provide meaningful positive feedback but is hindered when provided with negative or critical feedback (Ryan et al., 2009). This has been observed in PE setting as children's perceptions of their competence and enjoyment in PE influence children's physical activity engagement (Weiss, 2000). Moreover, perceived competence and enjoyment have been found to be significantly correlated during PE suggesting that enhancing students' perceived competence may be influence enjoyment (Fairclough, 2003). HIIT may serve to build feelings of competency in children as more structured and intensive physical activity was found to be associated with competence compared to unorganized and recreational activity (van Wersch, 1997; Telama, 1998). Thus, measuring children's perception of competency with

HIIT might reveal if this psychological need plays a role in children's physical activity behavior and enjoyment during this activity.

Enjoyment of Physical Education

Enjoyment has become particularly useful in understanding children's physical activity behaviors during PE. Enjoyment of physical activity is positively associated with physical activity participation among youth (Sallis et al., 2000; Motl et al., 2001). This may be due to its positive impact on intrinsic motivation to be physically active (Kremer et al., 1997; Wankel, 1993). It is interesting that these effects seem to generalize, with PE experience being strongly related to other physical activity. For example, children's enjoyment of PE is one of the strongest and most consistent correlates of physical activity outside of school (Cairney et al., 2012; Sallis et al., 1999). More recently researchers determined that childhood memories of enjoyment and non-enjoyment during PE are linked with attitudes toward physical activity, intention, and sedentary behavior into adulthood (Ladwig et al., 2018). Thus, it appears that ensuring a positive experience during PE class is essential for children's level of physical activity both within and outside of PE.

Enjoyment of HIIT in Existing School-Based HIIT Studies

Children's enjoyment of HIIT integrated within a school setting has been largely understudied. Costigan et al. (2015) piloted an 8-week RCT that incorporated 3 HIIT sessions of 8-10 minutes each week during PE or at lunch. The HIIT protocol consisted of two different HIIT conditions - cardiorespiratory exercises (i.e. shuttle runs, jumping jacks, skipping) or cardiorespiratory and body weight training exercises (e.g. squats, push-ups). These were compared to participants in typical PE and lunch activities. Enjoyment of HIIT was assessed among a sub-group of 9th to 10th grade students during the program evaluation who provided positive reviews of 4.2 (out of a 5-point Likert-type scale). While intriguing, this finding is limited by the lack of a theoretical consideration of enjoyment, small sample size (n=31), and limited generalizability beyond high school. Lambrick et al. (2015) assessed children's enjoyment of a series of game based HIIT activities during the school day. These were implemented twice per week by exercise specialists for 8-10 year old children to achieve a total of 1 hour of additional PE per week (Lambrick et al., 2015). While children enjoyed the protocol - with an average score 4.48 ± 0.24 (out of 5) - this study recruited a small sample size (n=55) through an intervention that would be challenging to disseminate given the use of specially trained personnel vs PE teachers and the additional time commitment. The latter is particularly concerning as HIIT is based on the premise of short duration exercise, making it potentially a highly efficient supplement to PE.

While autonomy and perceived competence have found to support children's engagement and liking for physical activity (Deci and Ryan, 1985, Sallis et al., 2000), less is known about children's preference for type of activity (high intensity, low intensity, strength). The existing literature has largely focused on children's preferences for sport participation (Duda, 1995; Gill, 1998), such that children are less likely to engage in individual exercise than team activities (Hovell et al., 1999). However, capturing children's liking and perceived competence of individual exercises such as within HIIT protocols is important for developing interventions and PE lessons that likely motivate children for sustained activity participation.

While HIIT is a potentially potent training method for children and a solution to the time limitations during PE, research is limited in assessing the viability of a school-based HIIT intervention. To date, no study has included: (a) a large, diverse sample across the elementary grades; (b) a generalizable design implemented through PE teachers; (c) a theoretical model to inform the design (d) or an understanding of children's preferences for individual exercises. Therefore, the aim of this study is to determine the feasibility of HIIT for the elementary PE classroom. It will be designed to describe children's physical activity levels, enjoyment, and competence of HIIT within a manipulation of a SDT framework of autonomy (teacher verse student choice of activity). A second aim is to determine children's enjoyment and competence towards high intensity, low intensity, and strength activities that make up the components of the study's HIIT protocol. Given that autonomy and competence have been associated with enjoyment, we hypothesize that enjoyment and competence will be higher in the autonomous (student choice) HIIT condition. Subsequently, we hypothesize that this increased enjoyment and competence will result in increased physical activity levels during the autonomous HIIT condition. Lastly, we hypothesize that students' enjoyment and competence for low intensity activity will be greater than high intensity activity and strength activity. While we do not have specific hypotheses, we will assess these differences as a function of sex and grade level.

Methods

Participants

After two months of recruitment, 80% of the 2nd-5th grade students obtained parental consent, 95% of these students assented to participate, and all three PE teachers consented to participate. This resulted in 3 PE teachers and 403, 2nd-5th grade students participating in the study. All study materials were approved by the Institutional Review Board for Human Subjects Research at The University of Texas at Austin. All procedures and materials were reviewed and approved by an elementary school district located in central Texas. Upon obtaining district approval, project staff met with the selected elementary school principal to discuss the project, and who also provided approval to conduct the intervention at the school. Once approved, physical education teachers and students were recruited across one academic year (2019-2020). Both parental consent and student assent were required for student participation. All physical education teachers (n=3) consented to participate (see Appendices).

Overview of Procedures

All students participated in a baseline period for three weeks prior to the study in which the HIIT program was PE teacher-led to familiarize and train the students with these exercises and the HIIT protocol. Then for the remainder of the school year, participants completed HIIT twice each week, consisting of a 15-minute warm-up including brief periods of walking, HIIT, and stretching. During the high intensity interval, students performed a series of exercises that included: push-ups, jumping jacks, curl ups, star jacks, mountain climbers, high knees, and running in place. During rest periods during the high intensity interval session, students completed flexibility exercises that included cobra stretch, straddle stretch, and child's pose.

Protocol

All PE classes in grades 2-5 were assigned to two conditions that included:

Non-Autonomous Condition (Teacher-Led). In the non-autonomous condition, their normally assigned certified physical education teachers facilitated the HIIT program during the daily warm-up and selected exercises to prepare students for the FITNESSGRAM® state mandated testing. A typical HIIT lesson lasted 5 minutes. The participants performed 7 high intensity or strength exercises for 30 seconds all-out with 10 seconds rest and low intensity stretching throughout. Every day consisted of the same structure with students working individually to complete each activity with instruction from their PE teacher.

Autonomous Condition (Student-Led). During the autonomous condition, students followed the same format of completing 7 exercises for 30 seconds all-out with 10 second rest. The primary differences were that students took turns selecting each exercise for the class to complete.

Order of condition was randomly assigned within each PE class.

MEASURES

Demographics. The parental informed consent form asked for the release of demographic data from the school's records. These data provided sex, age, race/ethnicity, and eligibility for free/reduced lunch as a proxy for a dichotomous indicator of SES. The final sample was fairly diverse being 49.4% female, 21.1% Latino or Hispanic, 59.6% white, 6.9% eligible for free/reduced lunch (yes/no), and 80.7% in the Healthy Fitness Zone (yes/no) for BMI as assessed classified by the FITNESSGRAM,® see Table 1 (Plowman & Meredith, 2013).

Fitness. Participant fitness was derived from the school FITNESSGRAM® records (Plowman & Meredith, 2013). FITNESSGRAM® is considered a valid and reliable measure of physical fitness (Plowman & Meredith, 2013). The FITNESSGRAM® includes tests of each component of fitness that for this school include: cardiorespiratory/aerobic fitness assessed through the PACER, a 20-m shuttle run; and muscular endurance as measured by push-ups and curl-ups. The school did not report flexibility using the sit-and-reach test. Each participants' PACER, push-up, and curl-up score were evaluated by the investigators using FITNESSGRAM® criterion-referenced standards to evaluate fitness performance. Muscular Strength performance is classified into two areas: the "Healthy Fitness Zone" (HFZ) and the "Needs Improvement" (NI) Zone. Body composition and aerobic capacity are classified by: the "Healthy Fitness Zone" (HFZ), the "Needs Improvement" (NI) Zone, and the "Needs Improvement-Health Risk Zone. Researcher dichotomized the fitness components into yes = in HFZ, no = not HFZ. Additionally, researchers completed the body composition component of the FITNESSGRAM® for the PE teachers. Physical assessments were conducted using sensitive methods so that weight and height were measured in a private setting, with only one student measured at a time. No values were called out or given to the student. A handheld display was used for the weight scale and kept away from the sight of the student. If the student requested their values, they were directed to speak with the school nurse about obtaining their values from the nurse. Children's weight was measured in kilograms (kg) using a Health o Meter® 320KL Medical Scale and height was measured in centimeters (cm) using the Portable Adult/Infant Measuring Unit® from Perspective Enterprises, model PE-AIM-101. Values were assessed using the metric system in case any of the privacy settings failed so that students would not easily understand the values. Demographic characteristics can be seen in Table I.

OUTCOMES MEASURES

All survey assessments were conducted by trained members of the research team with the help of the 3 PE teachers. The participants were blinded to the condition until the PE teacher provided instructions on the day of the PE session. Immediately following the HIIT session, students completed a two-item survey under exam-like conditions assessing enjoyment and competence with the activity type or HIIT condition.

Enjoyment and Competence. The survey developed by the researchers and three PE teachers contained two items assessed on a 5-point Likert scale that included: (1) “How did you enjoy the exercise?,” 1 (I did not enjoy it all) to 5 (I enjoyed it a lot), (2) “How do you think you did?,” 1 (I did really poorly) to 5 (I did really well). The enjoyment item was adapted from the validated Physical Activity Enjoyment Scale (PACES) but was condensed to one question (Moore et al., 2009). Prochaska et al. (2003) validated that this single measure of PE enjoyment as positively associated with similar descriptions of PE. To increase the accuracy of response, the Likert-type scale was supplemented with a visual analog displaying a gradient of “happy/sad faces” for each of the 5 possible responses. Research shows that these images improve response accuracy, particularly for youth (Lang, 1980). Students independently answered each of the questions.

Physical Activity. To determine the intensity of activity during HIIT, four classes from each grade were fitted with GTX3X+ accelerometers, comprising approximately 50.0% *(n=201)* of the total sample. To ensure a complete collection of school-week physical activity, accelerometers were distributed at the beginning of the school day by research staff and taken off as students left class at the end of each school day. For this measure, children’s physical activity was assessed with a triaxial accelerometer ActiGraph® Manufacturing Technologies, Inc. model GTX3X+ (Welk et al., 2004). The accelerometers were worn throughout the entire school-day in an elastic belt around the waist, positioned on the right hip (Trost et al., 2005). Data were collected in 5-second epochs to best capture children’s activity (Nettlefold et al., 2016). Periods of greater than 90 minutes of zero counts were defined as non-wear time (Choi et al., 2011). Counts were analyzed with ActiLife v6.13.4 software that applied Evenson cut points (Evenson et al., 2008; Trost et al., 2011). In ActiLife, filters were applied to HIIT times and weekly PE times, validated HIIT and weekly PE physical activity for each student. Outcomes for physical activity were: (1) weekly percent time in MVPA (percentage of MVPA during valid wear time), and (2) percent of MVPA spent during HIIT by condition. Students with all zeros counts or improper use (*n*=91) or outliers likely due to improper use (*n*=3) were excluded.

Data Analysis. All statistical analyses were conducted using IBM SPSS statistics for Macintosh, Version 26.0 (IBM Corp., 2019). The descriptive analyses were conducted as 4 (grade) by 2 (sex) MANCOVA on enjoyment and competence for type of activity (high intensity, strength, low intensity). In addition, these will be run again with BMI as a covariate. Significant interactions were decomposed into the simple effects of sex within each level of grade and post hoc comparisons using the Bonferroni adjustment. The primary hypotheses were assessed through a series of 2 way ANOVAs; 2 (condition) x 2 (sex) x 4 (grade), with repeated measures on the first factor (condition). Where significant interactions occur, they were decomposed into the simple effects of condition within each level of sex and grade and post hoc comparisons using the Bonferroni adjustment.

Results

Means, standard deviations, and sample sizes are show in Table 2. HIIT activities were categorized based upon type of activity (high intensity, low intensity, and strength). A list of the individual exercises for each type of activity is distinguished in Table 2. New variables were computed for each type of activity by taking the mean of the enjoyment scores and the mean of competence scores for individual exercises within that subgroup. For example, the average enjoyment score for high intensity activity was calculated by averaging participant's ratings of high knees, jumping jacks, running in place, mountain climbers, and star jacks.

ENJOYMENT AND COMPETENCE FOR TYPE OF ACTIVITY.

A 4 (grade) x 2 (sex) MANCOVA was performed on enjoyment and competence for type of activity (high intensity, strength, low intensity). The main effect of gender for each exercise type was significant for high intensity and strength enjoyment, F (1, 283) = 4.35, $p < .05$, F (1,283) = 7.89, $p < .05$, both with small effect sizes (η_{p2}= 0.017). However, low enjoyment was not significant, F (1, 283) = 1.52, p =.05, (η_{p2}= 0.018). Boys significantly enjoyed high and strength activity more than girls. To understand the association of fitness in this model, a 4 (grade) x 2 (sex) MANCOVA was performed on enjoyment and competence for type of activity (high, strength, low) with BMI as the covariate. The results of the MANCOVA are show in Table 3 and the means and standard deviations are show in Table 4 and Table 5. There was a significant effect of BMI for strength enjoyment only, F (1, 283) = 12.42, $p < .05$, this was a small effect (η_{p2}= 0.039). There was a significant main effect of gender for high, strength, and low exercise enjoyment, F (1, 283) = 2.57, $p < .05$, F (1,283) = 5.21, $p < .05$, and F (1, 283 = 25.79, $p < .05$), respectively. Post Hoc tests using the Bonferroni adjustment indicated that boys significantly enjoyed high intensity activity (d=0.30) and strength activity (d=0.27) more than girls, while girls enjoyed low intensity activity significantly more than boys (*d*=0.29) (Table 4, Figure 1). From this evidence it clear that gender is associated with children's enjoyment for type of activity.

MVPA, ENJOYMENT, AND COMPETENCE FOR AUTONOMY CONDITIONS

Three separate 4 (grade) x 2 (sex) x 2 (condition) ANOVAs with repeated measures on condition were performed with percent MPVA, enjoyment, and competence as the outcome variables (Table 6, Table 7, Table 8). Prior to conducting the formal analysis of the data, preliminary steps were taken to strengthen the validity of the conclusions. The studentized residuals and boxplots were first examined in order to identify possibly outlying values on the percent MVPA, and enjoyment and competence scores. Three observations were found on the boxplots and only with regard to the physical activity measurement for MVPA. These were likely due to measurement error with improper use of the accelerometer devices. However, a sensitivity study showed that deleting the scores did not change important study results. The statistical inference assumptions associated with factorial ANOVA were also assessed. Inspection of plots and descriptive statistics in each cell suggest that there are no serious departures from the normality assumption. In addition, the independence assumption was met, as the devices and questionnaires were individually administered. Further, Levene's test for the homogeneity of variance between conditions indicated that population cell variances are equal for percent MVPA at condition 1 and 2 at the .05 level, F (7, 176) = 1.001, p >0 .05, F (7, 176) = 1.002, p >0 .05, respectively. Levene's test of homogeneity of variance between conditions indicated that population cell variances are equal for enjoyment and competence at both conditions at the level of 0.05 level, F (7, 362) = .740, p >0 .05, F (7, 362) = .679, p >0 .05, F (7,

363) = 1.136, p >0 .05, F (7, 363) = 1.271, p >0 .05, for enjoyment and competence at condition 1 and condition 2 respectively.

Percent of Time Spent in MVPA. The results of the three ANOVAs are shown in Tables 7-9 and the means, standard deviations, and sample sizes are shown in Tables 10-14. For the percent MPVA ANOVA analysis, there was a significant main effect of grade, F (3,176) =4.335, p<0.05, which was a moderately large effect (η_{p2}= 0.70). Participants in grade 4 participated in a significantly lower percent of time in MVPA during HIIT compared to grades 3 and 5. There was a significant main effect of condition, F(1,176)=131.86, p<0.001, which was a moderate effect (η_{p2}= 0.49). During the autonomous HIIT condition, participants engaged in significantly less MVPA than during the non-autonomous HIIT condition. These effects were qualified by a significant interaction between grade and condition, F(3,176) = 10.76, p<0.001, which was a moderate effect (η_{p2}= 0.16). Post hoc comparisons using Bonferroni adjustment indicated that percent MVPA decreased significantly across conditions for participants in each grade level (Table 9, Figure 2). There was a significant interaction between condition and sex, F(1,176) =5.16, p<0.05, which was a small effect (η_{p2}= 0.03). Post hoc comparisons using Bonferroni adjustment indicated that percent MVPA was significantly lower for females compared to males in the autonomous condition (d = 0.25) (Table 10, Figure 3).

Student Ratings of Enjoyment. There was a significant main effect of condition F(1,362)=63.67, p<0.001, which was a small effect (η_{p2}= 0.15). Participants in the autonomous group enjoyed HIIT significantly more than the non-autonomous group. There was a significant interaction between condition and sex, F (1,362) =11.86, p<0.05, which was a very small effect (η_{p2}= 0.03). Post hoc comparisons using Bonferroni adjustment indicated that enjoyment of HIIT significantly increased in the autonomous condition compared to the non-autonomous condition for both males and females (d = 0.45) and that for the non-autonomous condition, males enjoyed HIIT significantly more than females (d = 0.66) (Table 12, Figure 4).

Student Perceptions of Competence. There was a significant main effect of condition, F (1, 363) =5.855, p<0.05, which was a small effect (η_{p2}= 0.016). Post hoc comparisons using Bonferroni adjustment indicated that competence of HIIT significantly increased in the autonomous conditions compared to the non-autonomous condition (d = 0.12) (Table 13, Figure 5).

Discussion

The first aim of this study was to investigate the effects of HIIT embedded within an SDT framework on children's MVPA, enjoyment, and perceived competency during PE. Overall, children tended to enjoy HIIT in both conditions making HIIT a potentially feasible school based physical activity intervention. While children significantly enjoyed (*M*=4.5, *SD*=0.87) and felt more competent (*M*=4.45, *SD*=0.74) on a 5-point scale during the autonomous HIIT condition compared to the nonautonomous HIIT condition, (*M*=4.08, *SD*=1.09; *M*=4.36, *SD*=0.80), percent MPVA was significantly lower in the autonomous condition (*M*=41.89, *SD*=12.16) compared to the nonautonomous condition (*M*=54.77, *SD* =11.51). Thus, it appears that there is a trade-off between enjoyment and level of physical activity within a HIIT protocol. The lower the activity intensity, the greater the enjoyment. As the time spent on activity was the same, the difference between conditions was due to differences in exercise intensity between the two conditions.

The second aim of this study was to examine children's enjoyment and competence of various high intensity, low intensity, and strength exercises to inform intervention design and understand children's exercise preferences. Differences in enjoyment for type of activity depended on sex. That is, females enjoyed low intensity activity (*M*=4.56, *SD* =0.55) more than males (*M*=4.38, *SD* =0.69) and males enjoyed high intensity activity (*M*=4.17, *SD* =0.72) and strength activity (*M*=3.96, *SD* =1.01) more than females (*M*=3.95, *SD* =0.75; *M*=3.67, *SD* =1.11). This finding can be used to inform PE teachers, interventionists, and researchers when designing physical activity programs to strongly consider male and female preferences for type of activity.

While children tended to enjoy both HIIT conditions, the preference for the autonomous protocol aligned with the principals of SDT (Ryan & Deci, 2000). Providing children with choice in HIIT was associated with a positive experience during HIIT as children expressed stronger feelings of competency and enjoyment. This aligns with a long history of PE research. PE teachers have been shown to be fundamental to facilitating autonomy and competency experiences for children that ultimately support students' intrinsic motivation towards physical activity (Vasconcellos et al., 2019). For teachers that do support autonomy in their classroom, students have increased motivation, classroom engagement, skill development, future intention to exercise, and academic achievement (Cheon et al., 2012). On the contrary, within the non-autonomous condition, PE teachers utilized a more authoritarian style when teaching the HIIT protocol, which lessened enjoyment and competence. Interestingly, the PE teachers in the present study expressed their own struggle to control disruptive classroom behavior when providing autonomy to the students during PE. They explained that their class sizes of approximately 75 students within a small gym environment were not conducive to an autonomous HIIT protocol if sufficient intensity, form, and time-efficiency were to be achieved. As a result, the remainder of the school year the PE teachers only allowed students to participate in the non-autonomous HIIT condition during the PE warm-up. Thus, while promoting autonomy is clearly beneficial for children's motivation and experiences with physical activity (Vasconcellos et al., 2019), understanding the challenge in providing choice while ensuring the PE teachers needs' are met is an important consideration in PE intervention design.

The results revealed that intensity of activity significantly decreased with increased enjoyment and competence in the autonomous condition compared to the non-autonomous condition. While enjoyment is an important outcome for promoting children's lifelong physical activity participation (Sallis et al., 1999), higher levels of MVPA in children are associated with better cardiometabolic risk factors outcomes including waist circumference, fasting insulin levels, BMI, and body fat (Ekelund, 2012; Wittmeier et al., 2008). There is preliminary evidence suggesting that the more time children spend in vigorous activity specifically, the greater reduction in risk of several risk factors including BMI and waist circumference, and the greater improvements in CRF (Carson et al., 2014; Gutin et al., 2005). For HIIT specifically, once achieved at an optimal dose, children experience improvements in CRF, SBP, vascular function, and RMR compared to moderate intensity physical activity (Garcia-Hermoso et al., 2016; Chuensiri et al., 2015; Cote et al., 2015). According to our results, while fostering autonomous experiences increases children's enjoyment, it seems to undermine intensity of activity – more notably for females. Therefore, both PE teachers and researchers face a challenge when attempting to balance enjoyment of HIIT and sufficient MVPA needed to improve fitness and other CVD risks factors, especially when implementing a large-scale intervention in the school setting. This balance must be considered with future HIIT interventions designed for children.

McKenzie et al. (1994) were pioneers in elucidating the importance of children's liking for activity units in elementary school PE for continued engagement in physical activity. They found that children enjoyed skill related activities (e.g. sports skills and body/limb coordination) over health-related activities (e.g. aerobic dance, circuits, jump rope). The investigators did not look at differences in sex, by intensity of activity, or impact of BMI. While Hovell et al. (1999) did not report children's enjoyment or competence towards type of exercise, the researchers did find that boys tended to engage in more moderate intensity activity and team activities than girls, suggesting a gender preference for types of activities. The present study adds to the existing literature by categorizing boy's and girl's liking for types of individual exercises (high intensity, low intensity, strength) to gain a sense of children's preferences for PE, HIIT activities, especially as they align with the outcomes of the FITNESSGRAM® (see Table 2). After generating an average for each type of exercise, overall 2nd-5th grade children seemed to generally enjoy and felt competent engaging in high intensity, low intensity, and strength activities. However, there were significant differences in enjoyment for each activity type by sex. Females seemed to enjoy low intensity activity (walking, cobra stretch, straddle stretch, child's pose) more than boys did. Males enjoyed high intensity (high knees, mountain climbers, jumping jacks, running in place, star jacks) and strength activities (pushups and curl ups) more than females did. CRF was not available as a variable for all four grades, and thus BMI was used as a proxy for fitness. After adjusting for BMI, sex remained a significant predictor of enjoyment for type of exercise, while grade was not associated with enjoyment for any exercise type. This then strengthens the argument for considering sex preferences regardless of fitness and age as an indicator of children's enjoyment for physical activity.

The finding for elementary aged females' preference for engaging in low intensity individual exercise is an important consideration for future interventions. Those hoping to impact young girl's lifelong physical activity patterns should consider implementing lower intensity activities like walking, flexibility, and yoga to include in interventions. In addition to picking girl-friendly exercises, Barr-Anderson et al. (2008) proposed several alternative solutions for fostering girl's enjoyment during PE. They suggest creating a noncompetitive and inclusive environment and building self-efficacy through skill-development over time. For girls, ensuring a positive experience in PE is critical because there is a stronger association between their enjoyment of PE class and physical activity levels than for boys. Moreover, their enjoyment of PE tends to be lower compared to boys and it decreases into adolescence (Treanor et al., 1998), which aligns with the decline of activity into adolescence (Grunbaum et al., 2004). Therefore, extra consideration for girl's perceptions of high intensity and strength exercise within training programs should be accounted for to support girl's physical activity engagement.

LIMITATIONS

The current study has several shortcomings. The first is the failure to achieve truly high intensity physical activity during HIIT. Given the number of students in our study and natural conditions of the experiment, we were unable to achieve the intended dose of activity. Additionally, we did not have the measures to establish that the participant's heart rate and/or $VO2_{max}$ to ensure the HIIT stimulus classification of greater than or equal to 70% $VO2_{peak}$ or the equivalent of HR_{max} was achieved (Bond et al., 2017). Our measure of intensity was limited to those participants who wore GTX3X+ accelerometers. Additionally, the HIIT protocol only lasted 5 minutes, which may not be long enough to provide training adaptions or health benefits. A second limitation was the inability to blind teachers to condition, which may have altered the students' and PE teacher behaviors. Finally, future studies should move beyond a simple two-item scale and consider a qualitative assessment of children's experience of HIIT and types of individual exercises to gain a more comprehensive understanding of their perceptions and assist in survey development. In addition to theory being the foundation of intervention design, input from the target audience is critical to determining feasibility, acceptability, and success of program options (Haglund, Weisbrod, & Bracht, 1990).

STRENGTHS

This was the first study to explore such a large number of children's perceptions of HIIT and various exercises that aligned with the FITNESSGRAM® outcomes. This allowed for sufficient power to test BMI as a covariate and to make meaningful comparisons between sex and grade. Second, while the naturalistic implementation limited intensity and duration of HIIT, the protocol was feasible and generalizable. Finally, the study was embedded within a SDT framework, which provides a clearer understanding of factors associated with enjoyment and perceived competence.

Future studies should consider how to achieve and measure a more optimal dose of HIIT, while simultaneously using SDT to maintain enjoyment and competence of HIIT within a school-based intervention. While PE teachers assisted in the protocol development, a more extensive process with student’s perceptions could bolster the present results. This might be especially important for girls. A follow-up study could compare pre/post HIIT intervention outcomes of aerobic fitness, BMI, enjoyment, and competence with that of a similarly matched control school. Given the extent of health outcomes provided by HIIT to children, a HIIT school-based intervention may be most beneficial in schools with a high number of children at risk for heart disease. This study is a first step to understanding the potential of this potent training method in the elementary school setting.

Conclusion

This is the largest study to date to assess HIIT in the elementary setting and one of the few to incorporate objective measures of physical activity and embed itself in a broader, psychological theory. Findings from this study highlight the challenge in designing physical activity interventions to achieve higher intensity physical activity with children while simultaneously striving to promote enjoyable exercise experiences. Autonomy significantly improved children's enjoyment and competency across HIIT activities but was resisted by PE teachers and resulted in lower intensity activity. As a result, children's ability to achieve sufficient intensity of HIIT might be compromised with a more positive experience of autonomous exercise. Therefore, future researchers need to consider the balance between children's psychological and physiological outcomes when attempting to intervene on children's physical activity behavior. Generally, children seem to enjoy and feel most competent engaging in low intensity activity compared to high intensity and strength activities. This was particularly true for females who preferred low intensity activity more than males, while males enjoy high intensity and strength activities more than females. Thus, sex differences for types of activity should be considered in interventions along with methods to develop more intense physical activity in girls over the course of the school year. Nonetheless, the results of this are promising for future interventions designed using HIIT as children seem to support this time-efficient form of interval training within the school setting.

Tables

Characteristics	All Subjects (n=403)	2nd Grade (n=111)	3rd Grade (n=104)	4th Grade (n=88)	5th Grade (n=100)
Age in years (M±SD)	8.94±1.24	7.45±0.5	8.38±0.45	9.47±0.50	10.40±.50
Sex *n (%)*					
Male	204 (50.6)	61 (55)	51 (49)	48 (54.5)	44 (44)
Female	199 (49.4)	50 (45)	53 (51)	40 (45.5)	56 (56)
Ethnicity *n (%)*					
Hispanic or Latino	97 (21.1)	20 (18)	22 (21.2)	21 (23.9)	34 (34)
Not Hispanic or Latino	304 (75.4)	90 (81.1)	81 (77.9)	67 (76.1)	66 (66)
Race *n (%)*					
African American or Black	20 (5)	6(5.4)	2 (1.9)	7(8)	5 (5)
White	240 (59.6)	69 (62.2)	71 (69.2)	50 (56.8)	49 (49)
Asian	29 (7.2)	10 (9)	4 (3.8)	7 (8)	8 (8)
Hispanic or Latino	96 (23.8)	20 (18)	22 (21.2)	20 (22.7)	34 (34)
Native Hawaiian or other Pacific Islander	1 (0.2)	-	1(1)	-	-
2 or more races	12 (3.2)	4 (3.6)	2(1.9)	3(3.4)	4(4)
Eligible for free/reduce lunch *n (%)*	28(6.9)	4(3.6)	10(9.6)	9(10.2)	5(5)
Weekly MVPA PE *n* (M±SD)	175 (28.20 ± 5.43)	41(29.43 ± 5.61)	47 (27.44 ± 3.03)	41 (30.23 ± 6)	46 (25.97 ± 5.76)
FITNESSGRAM *n (%)*					
BMI in HFZ	251 (80.7)	70 (80.5)	66 (71.7)	50 (62.5)	65 (67.7)
PACER in HFZ	88 (63.3)	-	-	26 (66.7)	62 (62)
Pushups in HFZ	221 (75.9)	-	89 (85.6)	66 (75.9)	66 (66)
Curlups in HFZ	172 (59.1)	-	68 (66)	45 (51.1)	59 (59)

Table 1: Descriptive Characteristics of Key Variables. *Note:* N = 403. Abbreviations: M, mean; SD, standard deviation

Characteristics	Enjoyment			Competence		
	N	*M*	*SD*	*N*	*M*	*SD*
High Intensity	343	4.06	0.72	343	4.28	0.58
High Knees	368	3.75	1.2	367	4.16	0.82
Mountain Climbers	369	3.72	1.2	368	4.01	0.97
Jumping Jacks	368	4.48	0.83	367	4.61	0.62
Running in Place	363	4.3	0.96	363	4.44	0.8
Star Jacks	365	4.0	1.14	365	4.19	0.91
Strength	353	3.78	1.08	350	4.02	0.86
Pushups	366	3.68	1.25	365	3.96	1
Curlups	365	3.87	1.30	363	4.06	1.06
Low Intensity	343	4.45	0.64	343	4.57	0.46
Walking	368	4.71	0.70	369	4.71	0.58
Cobra Stretch	366	4.51	0.89	365	4.6	0.65
Straddle Stretch	368	4.15	1.1	367	4.37	0.83
Child's Pose	365	4.42	1.01	364	4.6	0.69

Table 2: Descriptive Characteristics of Physical Education Warm-up Activities. *Note.* The maximum possible value = 5.

Source	*SS*	*df*	*MS*	Partial η2	*p*
BMI					
Enjoy High	0.53	1	0.53	0.004	>0.05
Enjoy Strength	12.42	1	12.42	0.039	< 0.05
Enjoy Low	0.10	1	0.10	0.001	>0.05
Competence High	1.97	1	1.97	0.02	>0.05
Competence Strength	8.92	1	8.92	0.042	< 0.05
Competence Low	0.11	1	0.11	0.002	>0.05
Sex					
Enjoy High	2.57	1	2.57	0.017	< 0.05
Enjoy Strength	5.21	1	5.21	0.017	< 0.05
Enjoy Low	2	1	2.0	0.018	< 0.05
Competence High	0.51	1	0.51	0.005	>0.05
Competence Strength	0.20	1	0.20	0.001	>0.05
Competence Low	0.30	1	0.3	0.005	>0.05
Grade					
Enjoy High	2.48	3	0.83	0.017	>0.05
Enjoy Strength	1.69	3	0.56	0.006	>0.05
Enjoy Low	0.93	3	0.28	0.008	>0.05
Competence High	0.63	3	0.21	0.007	>0.05
Competence Strength	1.90	3	0.64	0.009	>0.05
Competence Low	0.08	3	0.03	0.001	>0.05
Gender*Sex					
Enjoy High	1.44	3	0.48	0.01	>0.05
Enjoy Strength	0.06	3	0.02	0.00	>0.05
Enjoy Low	0.24	3	0.08	0.00	>0.05
Competence High	0.34	3	0.11	0.00	>0.05
Competence Strength	0.02	3	0.01	0.00	>0.05
Competence Low	0.22	3	0.07	0.00	>0.05
Error					
Enjoy High	144.43	274	0.53		
Enjoy Strength	304.15	274	1.11		
Enjoy Low	107.02	274	0.39		
Competence High	96.34	274	0.35		
Competence Strength	202.14	274	0.74		
Competence Low	59.16	274	0.22		
Total					
Enjoy High	4826.16	283			
Enjoy Strength	4448.25	283			
Enjoy Low	5764.88	283			
Competence High	5308.00	283			
Competence Strength	4838.00	283			
Competence Low	5999.50	283			

Table 3: Analysis of Variance for Activity Type (High Intensity, Low Intensity, Strength) by Sex and Gender.

Activity Type	Low Intensity	High Intensity	Strength
Male			
M	4.38*	4.17*	3.96*
SD	0.69	0.72	1.01
N	145	145	145
Female			
M	4.56*	3.95*	3.67*
SD	0.55	0.75	1.11
N	138	138	138
Combined			
M	4.47	4.06	3.82
SD	0.63	0.74	1.07
N	283	283	283

Table 4: Enjoyment of Activity Type for Sex. * $p < 0.05$ for sex group contrasts.

Activity Type	Low Intensity	High Intensity	Strength
Male			
M	4.38	4.34	4.07
SD	0.68	0.62	0.8
N	145	145	145
Female			
M	4.56	4.23	4.01
SD	0.55	0.57	0.84
N	138	138	138
Combined			
M	4.47	4.29	4.04
SD	0.63	0.6	0.87
N	283	283	283

Table 5: Competence of Activity Type for Sex.

Source	Sum of Squares	*df*	Mean Square	*F*	η_{p2}	*p*
Between						
Grade	1812.86	3	604.29	4.335	.70	<0.05
Sex	178.63	1	178.63	1.281	.01	>0.05
Grade*Sex	801.89	3	267.30	1.917	.03	>0.05
Error	24534.18	176	139.40			
Within						
Condition	14954.10	1	14954.10	131.858	.49	<0.001
Condition*Grade	3661.102	3	1220.37	10.76	.16	<0.001
Condition*Sex	584.75	1	584.76	5.16	.03	<0.05
Condition*Grade*Sex	307.83	3	102.61	.905	.02	>0.05
Error	19960.339	176	113.41			

Table 6: Analysis of Variance for Condition by Grade and Sex (Percent MVPA).

Source	Sum of Squares	*df*	Mean Square	*F*	η_{p2}	*p*
Between						
Grade	8.003	3	2.69	1.91	.02	>0.05
Sex	.55	1	.55	.40	.00	>0.05
Grade*Sex	.48	3	.16	.11	.00	>0.05
Error	504.11	362	1.39			
Within						
Condition	35.39	1	35.39	63.67	.15	<0.001
Condition*Grade	1.86	3	.62	1.11	.01	>0.05
Condition*Sex	6.60	1	6.59	11.86	.03	<0.05
Condition*Grade*Sex	.209	3	.070	.126	.00	>0.05
Error	201.20	362	.56			

Table 7: Analysis of Variance for Condition by Grade and Sex (Enjoyment).

Source	Sum of Squares	*df*	Mean Square	*F*	Partial eta Squared	*p*
Between						
Grade	5.75	1	1.917	2.194	.018	>0.05
Sex	.019	3	.019	.021	.000	>0.05
Grade*Sex	3.765	1	1.255	1.437	.012	>0.05
Error	317.095	363	.874			
Within						
Condition	1.461	1	1.461	5.855	.016	<0.05
Condition*Grade	.444	3	.148	.594	.005	>0.05
Condition*Sex	.843	1	.834	3.341	.009	>0.05
Condition*Grade* Sex	1.184	3	.395	1.581	.013	>0.05
Error	90.566	363	.249			

Table 8: Analysis of Variance for Condition by Grade and Sex (Competence).

Grade	Autonomy	No Autonomy	Combined
2nd Grade			
M	43.41_a	52.34_a	47.78
SD	10.40	12.94	8.57
N	48	47	95
3rd Grade			
M	45.27_a	54.90_a	50.08
SD	11.29	8.23	8.35
N	52	51	103
4th Grade			
M	33.18_a	56.74_a	45.04*
SD	8.99	12.64	8.42
N	47	45	92
5th Grade			
M	45.11_a	55.07_a	50.84
SD	13.44	11.86	8.59
N	47	58	105
Combined			
M	41.89_a	54.77_a	
SD	12.16	11.51	
N	194	201	

Table 9: Mean Percent MVPA, Standard Deviations, and Sample Sizes for Grade in each HIIT Condition. *Note.* * $p < 0.001$ for grade contrasts. Means in the same row sharing the same letter superscript differ at $p < .05$.

Sex	Autonomy	No Autonomy	Combined
Male			
M	43.35[a]*	54.15[a]	49.14
SD	11.82	11.98	8.44
N	101	104	205
Female			
M	40.37[a]*	55.43[a]	47.73
SD	12.37	11.01	8.54
N	93	97	190
Combined			
M	41.95[a]	54.92[a]	
SD	11.15	11.72	
N	194	201	

Table 10: Meant Percent MVPA, Standard Deviations, and Sample Sizes for Sex in each HIIT Condition. Note. * $p < 0.001$ for sex contrasts. Means in the same row sharing the same letter superscript differ at $p < .05$.

Grade	Autonomy	No Autonomy	Combined
2nd Grade			
M	4.62	4.26	4.44
SD	.79	1.04	.84
N	97	98	195
3rd Grade			
M	4.51	4.20	4.36
SD	.99	1.11	.83
N	97	98	195
4th Grade			
M	4.51	4.00	4.25
SD	.90	1.11	.83
N	86	86	172
5th Grade			
M	4.45	3.87	4.17
SD	.81	1.1	.84
N	98	98	196
Combined			
M	4.52_a	4.08_a	
SD	.87	1.09	
N	378	380	

Table 11: Mean Enjoyment, Standard Deviations, and Sample Sizes for Grade in each HIIT Condition. Note. * $p < 0.001$ for grade contrasts. Means in the same row sharing the same letter superscript differ at $p < .05$.

Sex	Autonomy	No Autonomy	Combined
Male			
M	4.47[a]	4.21[a]*	4.33
SD	.91	.82	.83
N	192	190	382
Female			
M	4.58[a]	3.95[a]*	4.28
SD	1.07	1.11	.84
N	186	190	376
Combined			
M	4.52[a]	4.08[a]	
SD	.87	1.09	
	378	380	

Table 12: Mean Enjoyment, Standard Deviations, and Sample Sizes for Sex in each HIIT Condition. Note. * $p < 0.05$ for sex contrasts. Means in the same row sharing the same letter superscript differ at $p < .05$.

Grade	Autonomy	No Autonomy	Combined
2nd Grade			
M	4.58	4.53	4.54
SD	.75	.74	.96
N	96	98	194
3rd Grade			
M	4.36	4.27	4.30
SD	.82	.89	.95
N	98	98	196
4th Grade			
M	4.51	4.33	4.41
SD	.66	.80	.94
N	86	86	172
5th Grade			
M	4.39	4.34	4.36
SD	.62	.67	.94
N	98	98	196
Combined			
M	4.45*	4.36*	
SD	.74	.80	
N	378	380	

Table 13: Mean Competence, Standard Deviations, and Sample Sizes for Grade in each HIIT Condition. Note. * $p < 0.05$ for condition contrasts.

Sex	Autonomy	No Autonomy	Combined
Male			
M	4.43	4.39	4.40
SD	.78	.82	.94
N	191	190	381
Female			
M	4.49	4.34	4.41
SD	.66	.75	.95
N	187	190	377
Combined			
M	4.45_a	4.36_a	
SD	.74	.80	
N	378	380	

Table 14: Mean Competence, Standard Deviations, and Sample Sizes for Sex in each HIIT Condition. Note. * p <0.05 for condition contrasts.

Figures

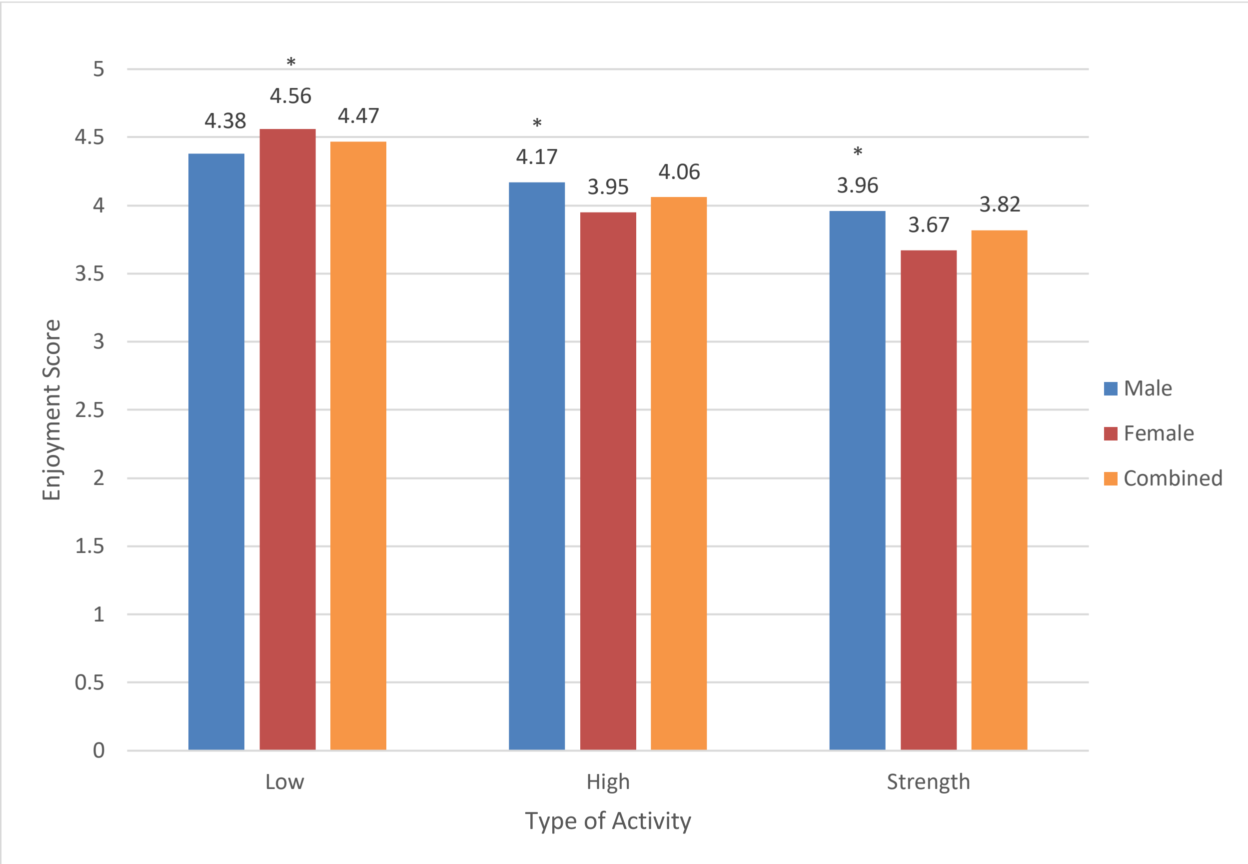


Figure 1: Enjoyment of Activity Type by Sex. Asterisks indicate significance ($p < 0.05$) for sex group contrasts in the MANCOVA.

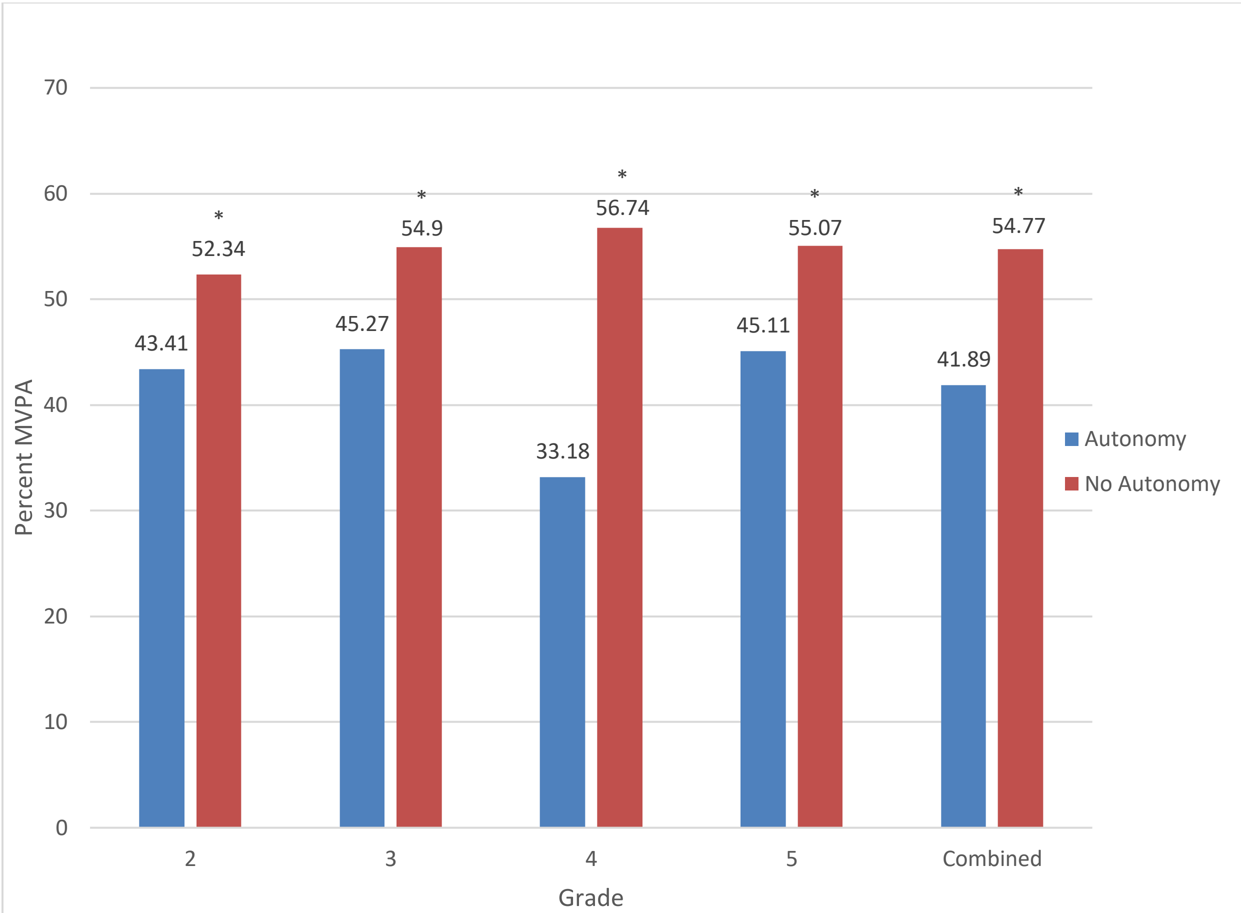


Figure 2: Mean Percent MVPA by Grade on Condition. Asterisks indicate significance ($p < 0.001$) for grade contrasts in the RM-ANOVA.

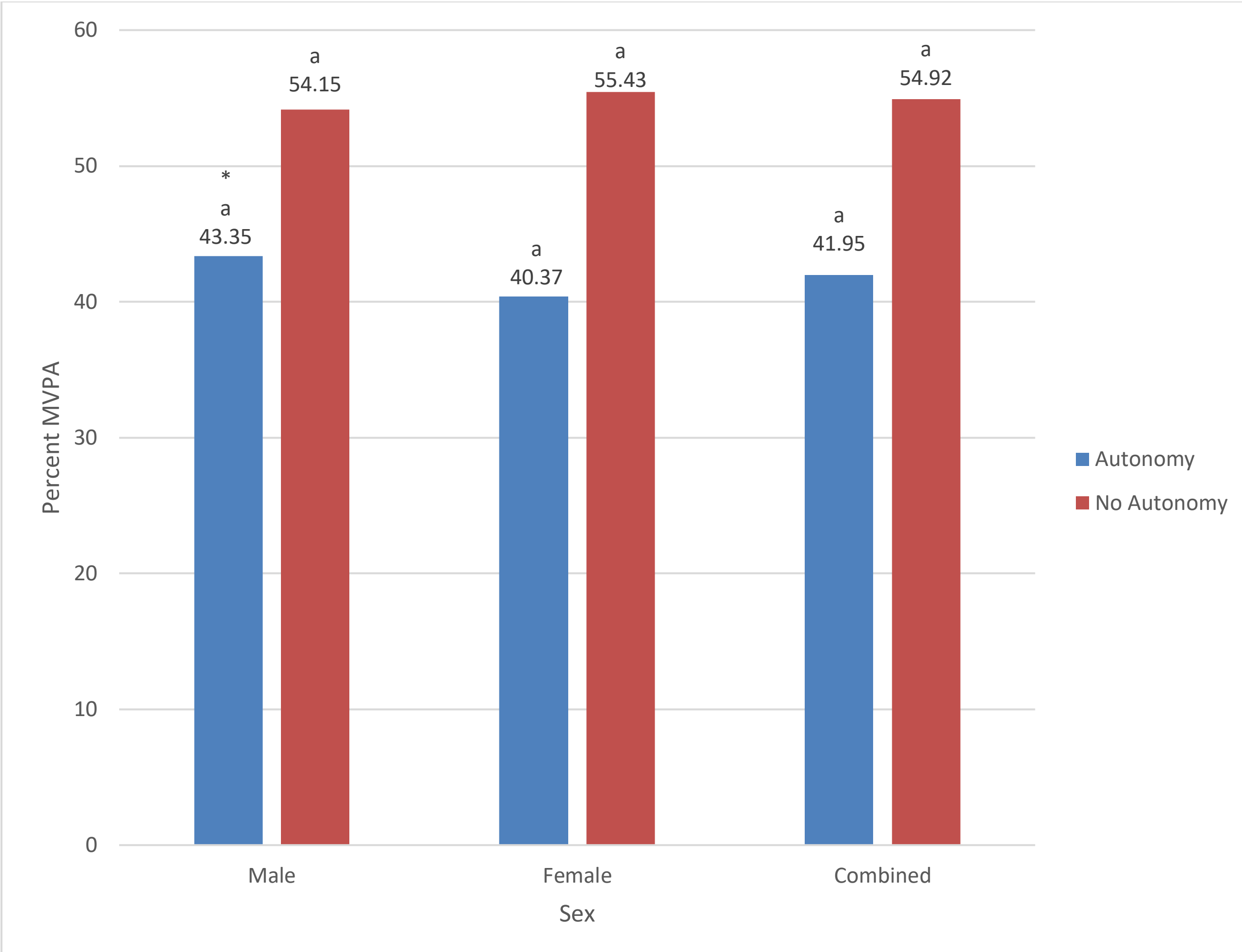


Figure 3: Mean Percent MVPA by Sex on Condition. Asterisks indicate significance ($p < 0.001$) for gender contrasts in the RM-ANOVA. Means sharing the same letter superscript differ at $p < .05$.

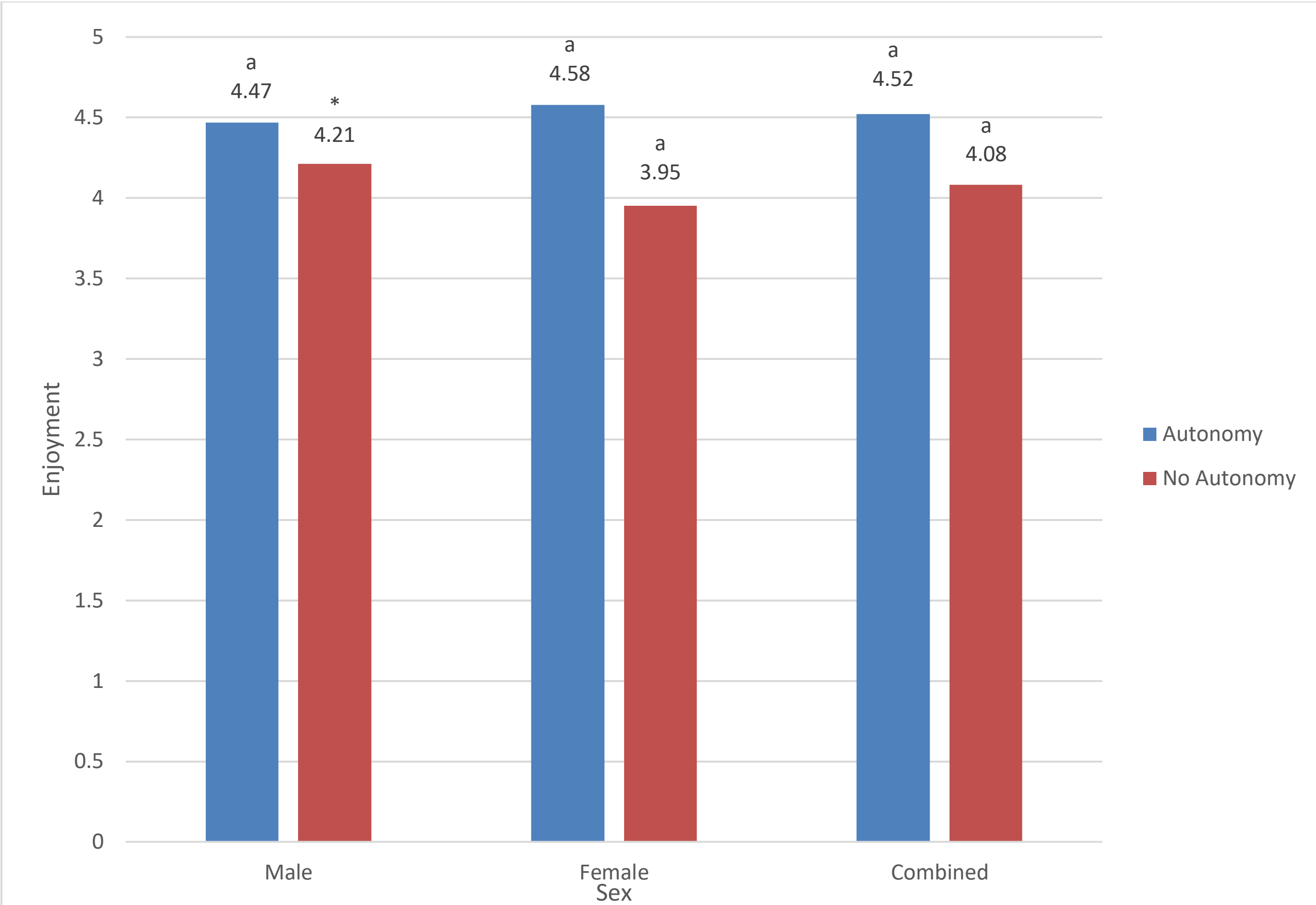


Figure 4: Mean Enjoyment by Sex on Condition. Asterisks indicate significance (p < 0.001) for gender contrasts in the RM-ANOVA. Means sharing the same letter superscript differ at p<05.

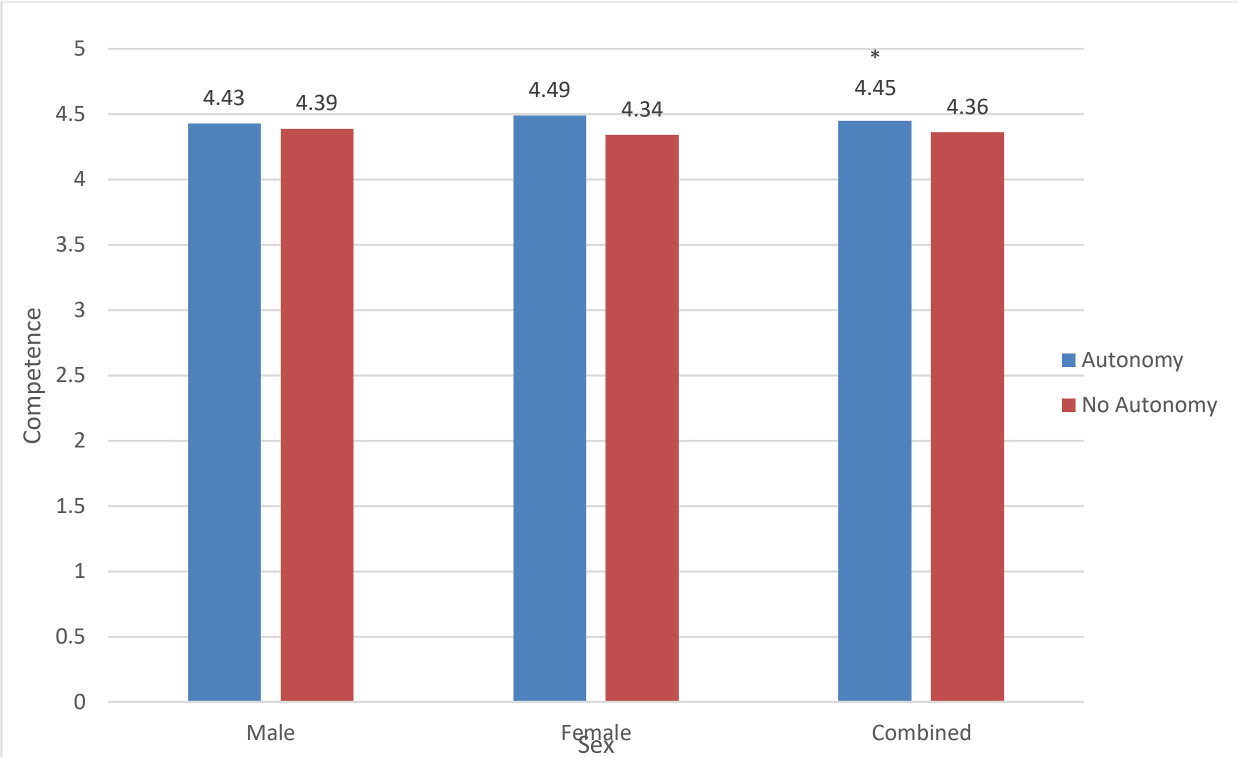


Figure 5: Mean Competence by Sex on Condition. Asterisks indicate significance (p <0.05) in the RM-ANOVA.

Appendices: A-E

APPENDIX A: IRB APPROVAL

OFFICE OF RESEARCH SUPPORT & COMPLIANCE

THE UNIVERSITY OF TEXAS AT AUSTIN

P.O. Box 7426, Austin, Texas 78713 · Mail Code A3200
(512) 471-8871 · FAX (512) 471-8873

FWA # 00002030

Date:	06/06/2019
PI:	John Bartholomew
Dept:	Kinesiology and Health Education
Title:	School Wide Adoption of Physically Active Learning

Re: IRB Expedited Initial Approval for Protocol Number 2019-05-0005

Dear John Bartholomew,

In accordance with the Federal Regulations, the Institutional Review Board (IRB) reviewed the above referenced research study and found it met the requirements for approval under the Expedited category noted below. The study is approved for the following period of time: 06/06/2019 to 06/05/2020. Approval ends at 12 a.m. midnight on approval end date. If the research will be conducted at more than one site, you may initiate research at any site from which you have a letter granting you permission to conduct the research. Retain a copy of the letter in your files.

Expedited category of approval:

☐ 1) Clinical studies of drugs and medical devices only when condition (a) or (b) is met. (a) Research on drugs for which an investigational new drug application (21 CFR Part 312) is not required. (Note: Research on marketed drugs that significantly increases the risks or decreases the acceptability of the risks associated with the use of the product is not eligible for expedited review). (b) Research on medical devices for which (i) an investigational device exemption application (21 CFR Part 812) is not required; or (ii) the medical device is cleared/approved for marketing and the medical device is being used in accordance with its cleared/approved labeling.

☐ 2) Collection of blood samples by finger stick, heel stick, ear stick, or venipuncture as follows: (a) from healthy, non-pregnant adults who weigh at least 110 pounds. For these subjects, the amounts drawn may not exceed 550 ml in an 8 week period and collection may not occur more frequently than 2 times per week; or (b) from other adults and children, considering the age, weight, and health of the subjects, the collection procedure, the amount of blood to be collected, and the frequency with which it will be collected. For these subjects, the amount drawn may not exceed the lesser of 50 ml or 3 ml per kg in an 8 week period and collection may not occur more frequently than 2 times per week.

APPENDIX B: STUDENT CONSENT FORM

INFORMED CONSENT TO PARTICIPATE IN RESEARCH

The University of Texas at Austin

School-Wide Adoption of Physically Active Learning

Your son/daughter is invited to participate in a study of children, physical activity, and academic performance. My name is John Bartholomew and I am a Professor at The University of Texas at Austin, Department of Kinesiology and Health Education. This study is part of my research involving how physical activity is related to in-class behavior and academic performance.

I am asking for permission to include your son/daughter in this study because they are in K through 5th grade at Forest Creek Elementary School. I expect to have over 900 students participate in the study.

Title of Research Study: School-Wide Adoption of Physically Active Learning

Principal Investigator(s), UT affiliation, and Telephone Number(s): John B Bartholomew, Ph.D., Professor, Department of Kinesiology & Health Education; 512-232-6021.

Funding source: N/A

What is the purpose of this study? The overall goal of the study is to determine effect of active learning on academic performance (Math, Language Arts, Social Studies, Science) and classroom behaviors, in K through 5th grade children. We anticipate that approximately 50 K through 5th grade teachers, 900 K through 5th students, across 1 elementary school, will be asked to participate in this study. Of those, we aim for an 85% consent rate.

What will be done if you allow your child to participate in this research study? If you allow your son/daughter to participate, he/she will be asked to do the following as part of a regular school day: 1) he/she will be asked to wear an accelerometer (step counter that measures intensity of activity) for 5 consecutive school days (1 week of school) between 7:30 am and 2:30 pm during the school year, 2) he/she will be asked to complete a short survey about how he/she likes the I-CAN! lessons (only will take 1 minute), and 3) we will ask them to describe the intensity and enjoyment of their P.E. lessons, 4) a randomly selected group of students will be asked mid-way through the semester, in grades K through 3rd to draw a picture to express their experience with the I-CAN! lessons; while randomly selected 3rd through 5th grade students will be asked to participate in a discussion about their experience with the lessons. Your consent will also provide us with the following information that we will obtain in a confidential way from the school and with no time required by the students: 1) we will obtain their scores on the fitness tests in P.E. (Fitnessgram), 2) we will obtain released reports from the district of their academic performance throughout the school year, including STAAR scores, 3) release demographic data (age, ethnicity, gender, free/reduced lunch status), 4) release Emergent Tree behavioral assessments from the school.

The Project Duration is: The project will begin August 1, 2019 and will end in June 2020. Your school will participate for only one school year within this period of time.

What are the possible discomforts and risks to your child? We have designed the study to be similar to the normal school day. The only difference would be the use of accelerometers and we try to minimize their impact by having these on a belt worn on top of the children's clothes. Thus, the risks are similar to the normal school day.

What are the possible benefits to your child or to other children? There are no direct benefits to the students. There are potential benefits to society at large. This intervention represents an attempt to increase physical activity without sacrificing instructional time.

If you choose for your child to take part in this study, will it cost you anything? Participation in this project is free of charge to all participants. Any supplies needed for participation will be provided to the child at no charge.

Will you or your child receive compensation for participation in this study? Students will receive a pencil for returning this consent form, whether or not you decide to let them participate. The University has no plan to provide compensation for a physical or psychological injury.

What if your child is injured because of the study? The children will engage in activities that are typical of a regular school day (activity similar to that of playing at recess or seen in P.E. class). As a result, no injuries are expected to occur from their participation. However, any child that is injured will be taken immediately to the school nurse for treatment. The University has no program or plan to provide treatment for research related injury or payment in the event of a medical problem. In the event of a research related injury, please contact the principal investigator.

If you do not want your child to take part in this study, what other options are available to your child? Your child's participation in this study is entirely voluntary. You are free to refuse for your child to be in the study, and your refusal will not influence current or future relationships with The University of Texas at Austin, *Forest Creek Elementary* and/or *Round Rock Independent School District*.

How can you withdraw your child from this research study and whom should you call if you have questions? If you or your child wishes to withdraw from this study at any time or if you have any questions at any time, you should contact the principal investigator, John B Bartholomew, at: 512-232-6021.

If you wish to stop your child's participation in this research study for any reason, you should contact the principal investigator: John B Bartholomew, Ph.D. at (512) 232-6021. You should also call the principal investigator for any questions, concerns, or complaints about the research. You are free to withdraw your consent and stop participation in this research study at any time without penalty or loss of benefits for which you may be entitled. Throughout the study, the researchers will notify you of new information that may become available and that might affect your decision to remain in the study. In addition, if you have questions about your child's rights as a research participant, or if you have complaints, concerns, or questions about the research, please contact the Office of Research Support at (512) 471-8871.

Any information that is obtained in connection with this study and that can be identified with your son/daughter will remain confidential and will be disclosed only with your permission. His or her responses will not be linked to his or her name or your name in any written or verbal report of this research project.

Your decision to allow your son/daughter to participate will not affect your or his or her present or future relationship with The University of Texas at Austin or with *Round Rock ISD*

How will the privacy and the confidentiality of your child's research records be protected? All identifying information will be removed from all data sheets. These sheets will be stored in a locked file cabinet within the Exercise and Sport Psychology Laboratory (BEL 849) at The University of Texas at Austin. In addition, no identifying information will be entered into the data file. Instead, student data will be filed under a random identification number, which will also be used on all electronic data. A master list of student names and their identification number will be created. This will be maintained in a separate, locked office, along with the keys to the file cabinets containing the stored data in the lab. In addition, children will be treated in such a manner that their data cannot be shared (accelerometers do not visually show data). Individual values will not be shared with any student, teacher, or principal.

You may keep the copy of this consent form.

If in the unlikely event it becomes necessary for the Institutional Review Board to review your child's research records, then The University of Texas at Austin will protect the confidentiality of those records to the extent permitted by law. The research records will not be released without your consent unless required by law or a court order. The data resulting from your child's participation may be made available to other researchers in the future for research purposes not detailed within this consent form. In these cases, the data will contain no identifying information that could associate you with it, or with your child's participation in any study.

If the results of this research are published or presented at scientific meetings, your child's identity will not be disclosed.

Will the researchers benefit from your child's participation in this study? At the end of this project, the researchers will discover the effectiveness of the Texas I-CAN! Curriculum and will be able to use this information to tailor future school interventions to reduce childhood obesity.

CONSENT

Signatures:

You are making a decision about allowing your son/daughter to participate in this study. Your signature below indicates that you have read the information provided above and have decided to allow him or her to participate in the study. If you later decide that you wish to withdraw your permission for your son/daughter to participate in the study, simply tell me. You may discontinue his or her participation at any time.

I grant consent for my child to participate in the Texas I-CAN! study:

☐ **YES** ☐ **NO**

____

Printed Name of Son/Daughter **Date**

____

Signature of Parent(s) or Legal Guardian **Date**

APPENDIX C: STUDENT ASSENT FORM

I agree to be in a study about children and physical activity. My parents explained this study to me and they said I could be in it. The only people who will know what I say and do will be the people in charge of the study.

I know that as a part of the study I will wear a little box on my waist that will count the number of steps that I take. I also know that the teacher will let them know how I did in math, language arts, science, and social studies. I know that I may be asked about how I feel about what I did in class. I know I may be asked to talk with the people in charge of the study during the middle of the year. I know that in P.E. I may be asked about how hard the workout feels and if I like it.

Writing my name on this page means that the page was read to me and that I agree to be in the study. I know what will happen to me. I can stop the study at any time if I want to and I will not get into trouble. If I want to stop, all I need to do is tell my teacher or the person in charge.

Print your name here: ____________________________________

Sign your name here: ____________________________________

Date: ___________

APPENDIX D: TEACHER CONSENT FORM

Teacher Informed Consent to Participate in Research
The University of Texas at Austin

School-Wide Adoption of Physically Active Learning

TEXAS I-CAN! (**T**exas **I**nitiatives for **C**hildren's **A**ctivity & **N**utrition) is designed to combat childhood obesity and related chronic diseases by developing physically active lesson units for school aged children. We are recruiting K through 5th grade teachers to provide a test of these lessons. We are contacting you because your principal indicated an interest in the program.

Title of Research Study: School-Wide Adoption of Physically Active Learning

Principal Investigator(s), UT affiliation, and Telephone Number(s): John B Bartholomew,
Ph.D., Professor, Department of Kinesiology & Health Education; 512-232-6021.

Funding source: N/A

What is the purpose of this study? The overall goal of the study is to determine the fitness and
in-school levels of physical activity levels due to the use of the I-CAN! lessons in K through 5th grade children; and if this physical activity is related to their behavior in class as well as their academic performance (Math, Language Arts, Social Studies, Science). We anticipate that approximately 50 K through 5th grade teachers, 900 K through 5th grade students, across 1 elementary school, will be asked to participate in this study. Of those, we aim for an 85% consent rate.

What will you be asked to do if you agree to participate in this research study? Teachers in school will be asked to: (1) attend training at the beginning of each semester to learn and review the Texas I-CAN! lessons and how they fit within your scope and sequence; (2) implement at least five Texas I-CAN! lessons per week. Each lesson requires 15 min to implement. We will ask you to track this along with lesson ratings on a monthly calendar, which will require approximately 1 min to complete.

All teachers will complete surveys at the beginning, middle, and end of the school year regarding efficacy of implementation, demographics, physical activity behaviors, conscientiousness, and perceptions about the school environment. The first two time periods for the surveys will be completed during school professional training days, and the last will be conducted after school hours at the end of the school year. Teachers will be asked to participate in focus groups at the beginning, mid-way through the year, and at the end of the school year to explore their experiences with the project. Focus groups will be audio-recorded. Additionally, teachers will be asked to wear an accelerometer to track physical activity intensity during the same week as their students.

The Project Duration is: The project will begin August 1, 2019 and will end in June 2020. Your school will participate for one school year during this time period.

What are the possible discomforts and risks? We have designed the study to be similar to the normal school day. As such, the risks are similar to the normal school day.

What are the possible benefits? You will be trained in the use of the Texas I-CAN! lessons, which may be of benefit in your classroom. There are potential benefits to society at large. This intervention represents an attempt to increase physical activity without sacrificing instructional time.

If you choose to take part in this study, will it cost you anything? Participation in this project is free of charge to all participants. Any supplies needed for participation will be provided at no charge.

Will you receive compensation for participation in this study? No participant will receive compensation for the project as it is a school-wide initiative to conduct active lessons in the academic classroom.

If you do not want to take part in this study, what other options are available? All teachers and students will be mandated to participate in the physically active lessons in their Math, Language Arts, Science, and Social Studies classes as per the school agreement to participate. However, your participation with regard to survey completion, wearing accelerometers, or participating in focus groups in this study is entirely voluntary. You may opt out of our releasing information or participating in the surveys. Your refusal to provide information via surveys and/or focus groups will not influence current or future relationships with The University of Texas at Austin, Forest Creek Elementary and/or Round Rock Independent School District.

How can you withdraw from this research study and whom should you call if you have questions? If you wish to withdraw from this study at any time or if you have any questions at

any time, you should contact the principal investigator, John B Bartholomew, at: 512-232-6021.
You are free to withdraw your consent and stop participation in this research study at any time without penalty or loss of benefits for which you may be entitled. Throughout the study, the researchers will notify you of new information that may become available and that might affect your decision to remain in the study.

In addition, if you have questions about your rights as a research participant, or if you have
complaints, concerns, or questions about the research, please contact the Office of Research
Support and compliance at (512) 471-8871.

Any information that is obtained in connection with this study and that can be identified with you
will remain confidential and will be disclosed only with your permission. Your responses will
not be linked to your name or school in any written or verbal report of this research project.

Your decision to participate will not affect your present or future relationship with The University of Texas at Austin or with your School District.

How will your privacy and the confidentiality be protected? All identifying information will be removed from all data sheets. These sheets will be stored in a locked file cabinet within the Exercise and Sport Psychology Laboratory (BEL 849) at The University of Texas at Austin. In addition, no identifying information will be entered into the data file. Instead, participant data will be filed under a random identification number, which will also be used on all electronic data. A master list of participant names and their identification number will be created. This will be maintained in a separate, locked office, along with the keys to the file cabinets containing the stored data in the lab. Focus group audio-records will be destroyed upon transcription.

You may keep the copy of this consent form.

If in the unlikely event it becomes necessary for the Institutional Review Board to review your research records, then the University of Texas at Austin will protect the confidentiality of those
records to the extent permitted by law. The research records will not be released without your
consent unless required by law or a court order. The data resulting from your participation may be made available to other researchers in the future for research purposes not detailed within this

consent form. In these cases, the data will contain no identifying information that could associate
you with it, or with your participation in any study.

If the results of this research are published or presented at scientific meetings, your identity will not be disclosed.

Signatures:

You are making a decision about participating in this study. Your signature below indicates that you have read the information provided above and have decided to participate in the study. If you later decide that you wish to withdraw from the study, simply tell Project staff. You may discontinue your participation at any time.

I consent to participate in this study:

____

Printed Name **Date**

____

Signature **Date**

APPENDIX E: HIIT ENJOYMENT AND COMPETENCE SURVEY

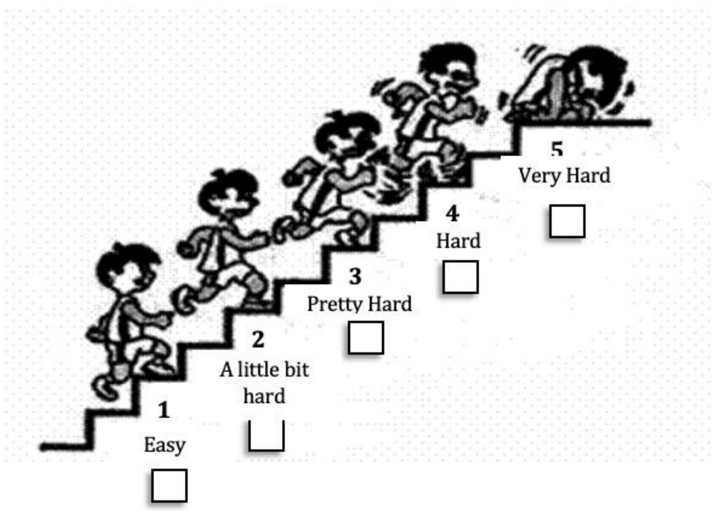
Directions: Please tell us how you feel doing these activities.

Exercise: **HIIT**

1. How did you enjoy the exercise?

I enjoyed it a lot	I enjoyed it a little	It was okay	I did not really enjoy it	I did not enjoy it at all
☐	☐	☐	☐	☐

2. How hard did you work?



3. How do you think you did?

I did really well.	I did well.	I did okay.	I did poorly.	I did really poorly.
☐	☐	☐	☐	☐

References

Andersen, L. B., Harro, M., Sardinha, L. B., Froberg, K., Ekelund, U., Brage, S., & Anderssen, S. A. (2006). Physical activity and clustered cardiovascular risk in children: A cross-sectional study (The European Youth Heart Study). *The Lancet*, *368*(9532), 299–304. https://doi.org/10.1016/S0140-6736(06)69075-2

Bailey, R. C., Olson, J., Pepper, S. L., Porszasz, J., Barstow, T. J., & Cooper, D. M. (1995). The level and tempo of children's physical activities: An observational study. *Medicine & Science in Sports & Exercise*, *27*(7), 1033.

Barry, V. W., Caputo, J. L., & Kang, M. (2018). The Joint Association of Fitness and Fatness on Cardiovascular Disease Mortality: A Meta-Analysis. *Progress in Cardiovascular Diseases*, *61*(2), 136–141. https://doi.org/10.1016/j.pcad.2018.07.00

Benjamin, E. J., Muntner, P., Alonso, A., Bittencourt, M. S., Callaway, C. W., Carson, A. P., Chamberlain, A. M., Chang, A. R., Cheng, S., Das, S. R., Delling, F. N., Djousse, L., Elkind, M. S. V., Ferguson, J. F., Fornage, M., Jordan, L. C., Khan, S. S., Kissela, B. M., Knutson, K. L., … On behalf of the American Heart Association Council on Epidemiology and Prevention Statistics Committee and Stroke Statistics Subcommittee. (2019). Heart Disease and Stroke Statistics—2019 Update: A Report From the American Heart Association. *Circulation*, *139*(10). https://doi.org/10.1161/CIR.0000000000000659

Bond, B., Weston, K. L., Williams, C. A., & Barker, A. R. (2017). Perspectives on high-intensity interval exercise for health promotion in children and adolescents. Open Access Journal of Sports Medicine, 8, 243–265.

Borrud L, Chiappa M, Burt V, et al. National Health and Nutrition Examination Survey: National Youth Fitness Survey plan, operations, and analysis, 2012. National Center for Health Statistics. Vital Health Stat 2(163). 2014.

Brage, S., Wedderkopp, N., Ekelund, U., Franks, P. W., Wareham, N. J., Andersen, L. B., & Froberg, K. (2004). Features of the Metabolic Syndrome Are Associated With Objectively Measured Physical Activity and Fitness in Danish Children: The European Youth Heart Study (EYHS). *Diabetes Care*, *27*(9), 2141–2148. https://doi.org/10.2337/diacare.27.9.2141

Brener ND, Demissie Z, McManus T, Shanklin SL, Queen B, Kann L. School Health Profiles 2016: Characteristics of Health Programs Among Secondary Schools. Atlanta: Centers for Disease Control and Prevention; 2017.

Cairney, J., Kwan, M.Y.W., Velduizen, S., Hay, J., Bray S.R., & Faught, B.E. (2012). Gender, perceived competence and the enjoyment of physical education in children: A longitudinal examination. *International Journal of Behavioral Nutrition and Physical Activity*, *9(26),* 1–8.

Carson, V., Rinaldi, R. L., Torrance, B., Maximova, K., Ball, G. D. C., Majumdar, S. R., Plotnikoff, R. C., Veugelers, P., Boulé, N. G., Wozny, P., McCargar, L., Downs, S., Daymont, C., Lewanczuk, R., & McGavock, J. (2014). Vigorous physical activity and longitudinal associations with cardiometabolic risk factors in youth.

International Journal of Obesity, *38*(1), 16–21. https://doi.org/10.1038/ijo.2013.135

Centers for Disease Control and Prevention. (2006). National Center for Health Statistics. National Health and Nutrition Examination Survey. Hyattsville, MD: U.S. Department of Health and Human Services.

Centers for Disease Control and Prevention. (2010). Strategies to Improve the Quality of Physical Education. U.S. Department of Health and Human Services, Atlanta, GA.

Centers for Disease Control and Prevention. (2013). A Guide for Developing Comprehensive School Physical Activity Programs. Atlanta, GA: Centers for Disease Control and Prevention, US Dept of Health and Human Services.

Center on Educational Policy. (2008). Instructional time in elementary schools: A closer look at changes for specific subjects. A report in the series From the Capital to the Classroom: Year 5 of the No Child Left Behind Act. Center on Educational Policy. Retrieved April 19, 2009, from http:// www.cep-dc.org/

Cheon, S. H., Reeve, J., & Moon, I. S. (2012). Experimentally Based, Longitudinally Designed, Teacher-Focused Intervention to Help Physical Education Teachers Be More Autonomy Supportive Toward Their Students. *Journal of Sport and Exercise Psychology*, *34*(3), 365–396. https://doi.org/10.1123/jsep.34.3.365

Choi, L., Liu, Z., Matthews, C. E., & Buchowski, M. S. (2011). Validation of Accelerometer Wear and Nonwear Time Classification Algorithm: *Medicine &*

Science in Sports & Exercise, *43*(2), 357–364. https://doi.org/10.1249/MSS.0b013e3181ed61a3.

Chu, N. F., Rimm, E. B., Wang, D. J., Liou, H. S., & Shieh, S. M. (1998). Clustering of cardiovascular disease risk factors among obese schoolchildren: The Taipei Children Heart Study. *The American Journal of Clinical Nutrition*, *67*(6), 1141–1146. https://doi.org/10.1093/ajcn/67.6.1141

Chuensiri, N., Tanaka, H., & Suksom, D. (2015). The Acute Effects of Supramaximal High-Intensity Intermittent Exercise on Vascular Function in Lean vs. Obese Prepubescent Boys. *Pediatric Exercise Science*, *27*(4), 503–509. https://doi.org/10.1123/pes.2015-0100

Corte de Araujo, A. C., Roschel, H., Picanço, A. R., do Prado, D. M. L., Villares, S. M. F., de Sá Pinto, A. L., & Gualano, B. (2012). Similar Health Benefits of Endurance and High-Intensity Interval Training in Obese Children. *PLoS ONE*, *7*(8), e42747. https://doi.org/10.1371/journal.pone.0042747

Costigan, S. A., Eather, N., Plotnikoff, R. C., Taaffe, D. R., & Lubans, D. R. (2015). High-intensity interval training for improving health-related fitness in adolescents: A systematic review and meta-analysis. *British Journal of Sports Medicine*, *49*(19), 1253–1261. https://doi.org/10.1136/bjsports-2014-094490

Cote, A. T., Phillips, A. A., Harris, K. C., Sandor, G. G. S., Panagiotopoulos, C., & Devlin, A. M. (2015). Obesity and Arterial Stiffness in Children: Systematic Review and Meta-Analysis. *Arteriosclerosis, Thrombosis, and Vascular Biology*, *35*(4), 1038–1044. https://doi.org/10.1161/ATVBAHA.114.305062

Deci, E.L. & Ryan, R.M. (1985). Intrinsic motivation and self-determination in human behavior (2nd ed.). New York: Plenum Press.

Duda, J. L. (1995). Motivation in sport settings: A goal perspective approach. In G. C. Roberts (Ed.), *Motivation in sport and exercise* (p. 57–91). Human Kinetics Books.

Ekelund, U. (2012). Moderate to Vigorous Physical Activity and Sedentary Time and Cardiometabolic Risk Factors in Children and Adolescents. *JAMA*, *307*(7), 704. https://doi.org/10.1001/jama.2012.156

Evenson, K. R., Catellier, D. J., Gill, K., Ondrak, K. S., & McMurray, R. G. (2008). Calibration of two objective measures of physical activity for children. *Journal of Sports Sciences*, *26*(14), 1557–1565. https://doi.org/10.1080/02640410802334196

Fairclough, S. (2003). Physical Activity, Perceived Competence and Enjoyment During High School Physical Education. *European Journal of Physical Education*, *8*(1), 5–18. https://doi.org/10.1080/1740898030080102

Fairclough, S. (2004). “Physical education makes you fit and healthy”. Physical education’s contribution to young people’s physical activity levels. *Health Education Research*, *20*(1), 14–23. https://doi.org/10.1093/her/cyg101

Froberg, K., & Andersen, L. B. (2005). Mini Review: Physical activity and fitness and its relations to cardiovascular disease risk factors in children. *International Journal of Obesity*, *29*(S2), S34–S39. https://doi.org/10.1038/sj.ijo.0803096

Garcia-Hermoso A, Cerrillo-Urbina AJ, Herrera-Valenzuela T, Cristi-Montero C, Saavedra JM, Martinez-Vizcaino V. Is high-intensity interval training more effective on improving cardiometabolic risk and aerobic capacity than other forms of exercise in overweight and obese youth? A meta-analysis. Obes Rev. 2016;17(6):531–540.

Gill, D.L. Gender differences in competitive orientation and sport participation. *Inter. J. Sport Psychol.* 19:145-159, 1988.

Grunbaum, J. A., Kann, L., Kinchen, S., Ross, J., Hawkins, J., Lowry, R., Harris, W. A., McManus, T., Chyen, D., & Collins, J. (2004). Youth risk behavior surveillance—United States, 2003. *Morbidity and Mortality Weekly Report. Surveillance Summaries (Washington, D.C.: 2002)*, *53*(2), 1–96.

Gutin, B., Yin, Z., Humphries, M. C., & Barbeau, P. (2005). Relations of moderate and vigorous physical activity to fitness and fatness in adolescents. *The American Journal of Clinical Nutrition*, *81*(4), 746–750. https://doi.org/10.1093/ajcn/81.4.746

Hagger, M. S., Chatzisarantis, N. L. D., Culverhouse, T., & Biddle, S. J. H. (2003). The Processes by Which Perceived Autonomy Support in Physical Education Promotes Leisure-Time Physical Activity Intentions and Behavior: A Trans-Contextual Model. *Journal of Educational Psychology*, *95*(4), 784–795. https://doi.org/10.1037/0022-0663.95.4.784

Haglund, B., Weisbrod, R. R., & Bracht, N. (1990). Assessing the community: its services, needs, leadership and readiness. N. Bracht (Ed.), Health Promotion at the Community Level, Sage, Newbury Park, CA.

Hallal, P. C., Victora, C. G., Azevedo, M. R., & Wells, J. C. K. (2006). Adolescent Physical Activity and Health: A Systematic Review. *Sports Medicine*, *36*(12), 1019–1030. https://doi.org/10.2165/00007256-200636120-00003

Hastie, P. A., Rudisill, M. E., & Wadsworth, D. D. (2013). Providing students with voice and choice: Lessons from intervention research on autonomy-supportive climates in physical education. *Sport, Education and Society*, *18*(1), 38–56. https://doi.org/10.1080/13573322.2012.701203

Heath, G. W., Parra, D. C., Sarmiento, O. L., Andersen, L. B., Owen, N., Goenka, S., Montes, F., & Brownson, R. C. (2012). Evidence-based intervention in physical activity: Lessons from around the world. *The Lancet*, *380*(9838), 272–281. https://doi.org/10.1016/S0140-6736(12)60816-2

Hollis, J. L., Williams, A. J., Sutherland, R., Campbell, E., Nathan, N., Wolfenden, L., Morgan, P. J., Lubans, D. R., & Wiggers, J. (2016). A systematic review and meta-analysis of moderate-to-vigorous physical activity levels in elementary school physical education lessons. *Preventive Medicine*, *86*, 34–54. https://doi.org/10.1016/j.ypmed.2015.11.018

Hovell, M. F., Sallis, J. F., Kolody, B., & McKenzie, T. L. (1999). Children's Physical Activity Choices: A Developmental Analysis of Gender, Intensity Levels, and Time. *Pediatric Exercise Science*, *11*(2), 158–168. https://doi.org/10.1123/pes.11.2.158

IBM Corp. (2019). IBM SPSS Statistics for Windows, Version 26.0. Armonk, NY: IBM Corp.

Jago, R., McMurray, R. G., Bassin, S., Pyle, L., Bruecker, S., Jakicic, J. M., Moe, E., Murray, T., & Volpe, S. L. (2009). Modifying Middle School Physical Education: Piloting Strategies to Increase Physical Activity. *Pediatric Exercise Science*, *21*(2), 171–185. https://doi.org/10.1123/pes.21.2.171

Janssen, I., & LeBlanc, A. G. (2010). Systematic review of the health benefits of physical activity and fitness in school-aged children and youth. *International Journal of Behavioral Nutrition and Physical Activity*, *7*(1), 40. https://doi.org/10.1186/1479-5868-7-40

Kahan, D., & McKenzie, T. L. (2017). Energy expenditure estimates during school physical education: Potential vs. reality? *Preventive Medicine*, *95*, 82–88. https://doi.org/10.1016/j.ypmed.2016.12.008

Katzmarzyk, P. T., Malina, R. M., & Bouchard, C. (1999). Physical Activity, Physical Fitness, and Coronary Heart Disease Risk Factors in Youth: The Québec Family Study. *Preventive Medicine*, *29*(6), 555–562. https://doi.org/10.1006/pmed.1999.0592

Kessler, H. S., Sisson, S. B., & Short, K. R. (2012). The Potential for High-Intensity Interval Training to Reduce Cardiometabolic Disease Risk: *Sports Medicine*, *42*(6), 489–509. https://doi.org/10.2165/11630910-000000000-00000

Kremer, J., Trew, K. and Ogle, S. (eds) (1997). Young People's Involvement in Sport. *International Review for the Sociology of Sport.*

Kriemler, S., Meyer, U., Martin, E., van Sluijs, E. M. F., Andersen, L. B., & Martin, B. W. (2011). Effect of school-based interventions on physical activity and fitness in children and adolescents: A review of reviews and systematic update. *British Journal of Sports Medicine*, *45*(11), 923–930. https://doi.org/10.1136/bjsports-2011-090186

Ladwig, M. A., Vazou, S., & Ekkekakis, P. (2018). "My Best Memory Is When I Was Done with It": P.E. Memories Are Associated with Adult Sedentary Behavior. *Translational Journal of the American College of Sports Medicine*, *3(16*), 119.

Lambrick, D., Westrupp, N., Kaufmann, S., Stoner, L., & Faulkner, J. (2016). The effectiveness of a high-intensity games intervention on improving indices of health in young children. *Journal of Sports Sciences*, *34*(3), 190–198. https://doi.org/10.1080/02640414.2015.1048521

Lang, P. J. (1980). Self-assessment manikin. Gainesville, FL: The Center for Research in Psychophysiology, University of Florida

Lee, I. M., Paffenbarger, R. S., & Hennekens, C. H. (1997). Physical activity, physical fitness and longevity. *Aging Clinical and Experimental Research*, *9*(1–2), 2–11. https://doi.org/10.1007/BF03340123

Li, X. and Dunham, P. (1993) Fitness load and exercise time in secondary physical education classes. *Journal of Teaching in Physical Education*. 12, 180–187.

Lee, I. M., Paffenbarger, R. S., & Hennekens, C. H. (1997). Physical activity, physical fitness and longevity. *Aging Clinical and Experimental Research*, *9*(1–2), 2–11. https://doi.org/10.1007/BF03340123

Martínez, S. R., Ríos, L. J. C., Tamayo, I. M., Almeida, L. G., López-Gomez, M. A., & Jara, C. C. (2016). An After-School, high-intensity, interval physical activity programme improves health-related fitness in children. *Motriz: Revista de Educação Física*, *22*(4), 359–367. https://doi.org/10.1590/s1980-6574201600040022

McKenzie, T. L., Alcaraz, J. E., & Sallis, J. F. (1994). Assessing Children's Liking for Activity Units in an Elementary School Physical Education Curriculum. *Journal of Teaching in Physical Education*, *13*(3), 206–215. https://doi.org/10.1123/jtpe.13.3.206

McKenzie, T. L., Nader, P. R., Strikmiller, P. K., Yang, M., Stone, E. J., Perry, C. L., Taylor, W. C., Epping, J. N., Feldman, H. A., Luepker, R. V., & Kelder, S. H. (1996). School Physical Education: Effect of the Child and Adolescent Trial for Cardiovascular Health. *Preventive Medicine*, *25*(4), 423–431. https://doi.org/10.1006/pmed.1996.0074

McKenzie T. L., Marshall S.J., Sallis J.F., Conway T.L. (2000). Student activity levels, lesson context, and teacher behavior during middle school physical education. *Res Q Exercise Sport*, *71(3*): *249-259.*

Moore, J. B., Yin, Z., Hanes, J., Duda, J., Gutin, B., & Barbeau, P. (2009). Measuring Enjoyment of Physical Activity in Children: Validation of the Physical Activity Enjoyment Scale. *Journal of Applied Sport Psychology*, *21*, S116–S129. https://doi.org/10.1080/10413200802593612

Motl, R. W., Dishman, R. K., Saunders, R., Dowda, M., Felton, G., & Pate, R. R. (2001). Measuring enjoyment of physical activity in adolescent girls. *American Journal of*

Preventive Medicine, *21*(2), 110–117. https://doi.org/10.1016/S0749-3797(01)00326-9

Must, A. (1999). The Disease Burden Associated With Overweight and Obesity. *JAMA*, *282*(16), 1523. https://doi.org/10.1001/jama.282.16.1523

National Center for Health Statistics. (2005-06). National Health and Nutrition Examination Survey. Hyattsville, MD: U.S. Department of Health and Human Services, CDC, National Center for Health Statistics.

National Physical Activity Plan Alliance. (2018). The 2018 United States Report Card on Physical Activity for Children and Youth. Washington, DC: National Physical Activity Plan Alliance, 2018.

Nettlefold, L., Naylor, P. J., Warburton, D. E. R., Bredin, S. S. D., Race, D., & McKay, H. A. (2016). The Influence of Epoch Length on Physical Activity Patterns Varies by Child's Activity Level. *Research Quarterly for Exercise and Sport*, *87*(1), 110–123. https://doi.org/10.1080/02701367.2015.1129046

Piercy, K. L., Troiano, R. P., Ballard, R. M., Carlson, S. A., Fulton, J. E., Galuska, D. A., George, S. M., & Olson, R. D. (2018). The Physical Activity Guidelines for Americans. *JAMA*, *320*(19), 2020. https://doi.org/10.1001/jama.2018.14854

Plowman, S.A. & Meredith, M.D. (Eds.). (2013). Fitnessgram/Activitygram Reference Guide (4th Edition). Dallas, TX: The Cooper Institute.

Powell, K. E., Thompson, P. D., Caspersen, C. J., & Kendrick, J. S. (1987). Physical Activity and the Incidence of Coronary Heart Disease. *Annual Review of*

Public Health, *8*(1), 253–287. https://doi.org/10.1146/annurev.pu.08.050187.001345.

Prochaska, J. J., Sallis, J. F., Slymen, D. J., & McKenzie, T. L. (2003). A Longitudinal Study of Children's Enjoyment of Physical Education. *Pediatric Exercise Science*, *15*(2), 170–178. https://doi.org/10.1123/pes.15.2.170

Ramos, J. S., Dalleck, L. C., Tjonna, A. E., Beetham, K. S., & Coombes, J. S. (2015). The Impact of High-Intensity Interval Training Versus Moderate-Intensity Continuous Training on Vascular Function: A Systematic Review and Meta-Analysis. *Sports Medicine*, *45*(5), 679–692. https://doi.org/10.1007/s40279-015-0321-z

Reeve, J. (2002). Self-determination theory applied to educational settings. In E. L. Deci & R. M. Ryan (Eds.), *Handbook of self-determination research* (p. 183–203). University of Rochester Press.

Ryan, R. M., & Deci, E. L. (2000). Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. *American Psychologist*, *55*.

Ryan, R. M., Williams, G. C., Patrick, H., & Deci, E. L. (2009). Self-determination theory and physical activity: The dynamics of motivation in development and wellness. *Hellenic Journal of Psychology*, *6*(2), 107–124.

Sallis, J. F., Prochaska, J. J., Taylor, W. C., Hill, J. O., & Geraci, J. C. (1999). Correlates of physical activity in a national sample of girls and boys in Grades 4 through 12. *Health Psychology*, *18*(4), 410–415. https://doi.org/10.1037/0278-6133.18.4.410

Sallis, J. F., Prochaska, J. J., & Taylor, W. C. (2000). A review of correlates of physical activity of children and adolescents: *Medicine & Science in Sports & Exercise*, 963–975. https://doi.org/10.1097/00005768-200005000-00014

Sallis, J. F., McKenzie, T. L., Beets, M. W., Beighle, A., Erwin, H., & Lee, S. (2012). Physical Education's Role in Public Health: Steps Forward and Backward Over 20 Years and HOPE for the Future. *Research Quarterly for Exercise and Sport*, *83*(2), 125–135. https://doi.org/10.1080/02701367.2012.10599842

SHAPE America. (2015). The essential components of physical education. Reston, VA: Author.

Simons-Morton B.G., Taylor W.C., Snider S.A., Huang I.W., Fulton J.E. (1994). Observed levels of elementary and middle school children's physical activity during physical education classes. *Prev Med. 23(4):* 437-441

Sola, K., Brekke, N., & Brekke, M. (2010). An activity-based intervention for obese and physically inactive children organized in primary care: Feasibility and impact on fitness and BMI: A one-year follow-up study. *Scandinavian Journal of Primary Health Care*, *28*(4), 199–204. https://doi.org/10.3109/02813432.2010.514136

Telma, R. (1998). Psychological background of a physically active lifestyle among European youth. In: R. Naul, K. Hardman, M. Pieron and B. Skirsted (Eds.), Physical Activty and Active Lifestyles of Children and Youth. Schorndorf, Karl Hofmann. pp 63-74.

Telama, R., Yang, X., Viikari, J., Välimäki, I., Wanne, O., & Raitakari, O. (2005). Physical activity from childhood to adulthood. *American Journal of Preventive Medicine*, *28*(3), 267–273. https://doi.org/10.1016/j.amepre.2004.12.003

Treanor, L., Graber, K., Housner, L., & Wiegand, R. (1998). Middle School Students' Perceptions of Coeducational and Same-Sex Physical Education Classes. *Journal of Teaching in Physical Education*, *18*(1), 43–56. https://doi.org/10.1123/jtpe.18.1.43

Trost, S. G., Mciver, K. L., & Pate, R. R. (2005). Conducting Accelerometer-Based Activity Assessments in Field-Based Research: *Medicine & Science in Sports & Exercise*, *37*(Supplement), S531–S543. https://doi.org/10.1249/01.mss.0000185657.86065.98

Trost, S. G., Loprinzi, P. D., Moore, R., & Pfeiffer, K. A. (2011). Comparison of Accelerometer Cut Points for Predicting Activity Intensity in Youth: *Medicine & Science in Sports & Exercise*, *43*(7), 1360–1368. https://doi.org/10.1249/MSS.0b013e318206476e

U.S. Department of Health and Human Services. (1996). Physical Activity and Health: A Report of the Surgeon General. Atlanta, GA: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion, 1996.

U.S. Department of Health and Human Services, CDC, National Center for Health Statistics. (2011-2012). National Center for Health Statistics. National Health and Nutrition Examination Survey. Hyattsville, MD:2011-12.

U.S. Department of Health and Human Services. (2016). The Child & Adolescent Health Measurement Initiative (CAHMI). National Survey of Children's Health. Data Resource Center for Child and Adolescent Health

U.S. Department of Health and Human Services (2018). 2018 Physical Activity Guidelines Advisory Committee. 2018 Physical Activity Guidelines Advisory Committee Scientific Report. Washington, DC: U.S. Department of Health and Human Services, 2018.

Wang, Y., Cai, L., Wu, Y., Wilson, R. F., Weston, C., Fawole, O., Bleich, S. N., Cheskin, L. J., Showell, N. N., Lau, B. D., Chiu, D. T., Zhang, A., & Segal, J. (2015). What childhood obesity prevention programmes work? A systematic review and meta-analysis: Childhood obesity prevention. *Obesity Reviews*, *16*(7), 547–565.

Wankel, L.M. (1993). The importance of enjoyment to adherence and psychological benefits from physical activity, *International Journal of Sport Psychology*, *24,* 151–169.

Weiss, M.R. (2000). Motivating kids in physical activity. President’s Council on Physical Fitness and Sports. Research Digest, 3(11):1-8.

Weiss, R., & Raz, I. (2006). Focus on childhood fitness, not just fatness. *The Lancet*, *368*(9532), 261–262. https://doi.org/10.1016/S0140-6736(06)69051-X

Welk, G. J., Schaben, J. A., & Morrow, J. R. (2004). Reliability of accelerometry-based activity monitors: A generalizability study. *Medicine and Science in Sports and Exercise*, *36*(9),

Wittmeier, K. D. M., Mollard, R. C., & Kriellaars, D. J. (2008). Physical Activity Intensity and Risk of Overweight and Adiposity in Children. *Obesity*, *16*(2), 415–420. https://doi.org/10.1038/oby.2007.73

World Health Organization. Cardiovascular Diseases. (2020). Retrieved March 09, 2020, from https://www.who.int/health-topics/cardiovascular-diseases/

Vasconcellos, D., Parker, P. D., Hilland, T., Cinelli, R., Owen, K. B., Kapsal, N., Lee, J., Antczak, D., Ntoumanis, N., Ryan, R. M., & Lonsdale, C. (2019). Self-determination theory applied to physical education: A systematic review and meta-analysis. *Journal of Educational Psychology*. https://doi.org/10.1037/edu0000420

van Sluijs, E. M. F., McMinn, A. M., & Griffin, S. J. (2007). Effectiveness of interventions to promote physical activity in children and adolescents: Systematic review of controlled trials. *BMJ*, *335*(7622), 703. https://doi.org/10.1136/bmj.39320.843947.BE

van Wersch, A., Trew, K, and Turner, I. (1990). Pupil's percieved physical competence and its implications for the new PE curriculum. British Journal of Physical Educaiton Research Supplement, 7: 1-5.

Xu J.Q., Murphy S.L., Kochanek K.D., Bastian B., Arias E. (2018) Deaths: Final data for 2016. *National Vital Statistics Reports, 67* (5), https://www.cdc.gov/nchs/data/nvsr/nvsr67/nvsr67_05.pdf.